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GEOGRAPHIC VARIATION IN EASTERN NORTH AMERICAN SAVANNAH SPARROWS

(*Passerculus sandwichensis*)

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In attempting to identify Ohio specimens of the Savannah sparrow, the writer was confronted with the usual difficult problem familiar to investigators in this confusing group of birds. He was not long in discovering what had already been suspected, that more than one geographic race is represented rather regularly among Ohio migrants, and furthermore, that not only are there numerous examples among the transients difficult of analysis, but that the breeding stock of the state was of doubtful racial affiliation as well. It was then realized that a thorough review of the geographic variation of Savannah sparrows breeding in eastern North America would be necessary to become personally familiar with the different characters and their combinations, as well as individual variations, found in breeding populations from as many different localities as it was possible to obtain material. In connection with this study 235 breeding birds including all the known races from North America, (with the exception of Pacific coast forms) have been examined, as well as numerous migrants totaling 1,087 specimens.

Peters and Griscom in their monographic work on the "Geographical Variation in the Savannah Sparrow"[1] divided the birds of this species breeding in Canada and the United States, east of the one hundredth meridian, into five races: *Passerculus sandwichensis nevadensis* Grinnell, *P. s. oblitus* Peters and Griscom, *P. s. labradorius* Howe, *P. s. savanna* (Wilson) and *P. s. princeps* Maynard. These authors con-

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[1]Bull. Mus. Comp. Zool., Vol. 80, No. 13, 1938, pp. 445–481.

sidered *P. s. bradburyi* Figgins and *P. s. campestris* Taverner as synonyms of *savanna* and *nevadensis* respectively.

These conclusions were borne out completely by the material examined in the present study, with the exception of the status of certain breeding populations included under the name *P. s. savanna*, and the identification of the type specimen of *P. s. bradburyi*.

Peters and Griscom commented on certain individual variations in specimens included by them under *P. s. savanna*. They did not, however, mention any variations in this form correlated at all with geographic distribution.

The present writer examined large series of breeding birds from Nova Scotia, New England, southern Ontario, Ohio and Michigan together with scattering specimens from regions in between; also a few from southern Wisconsin and northern Illinois and found a rather considerable amount of geographic variation. Generally speaking an increase in darkness and grayishness of plumage is noticeable in progressing westward to Michigan with a progressive paling from there on. Nova Scotia and the Magdalen Islands are inhabited by a comparatively pale, brownish bird. New England and Gaspé Peninsula specimens are noticeably darker and more grayish. From there westward there is a gradual darkening of color although northeastern Ohio and Lake Nipissing, Ontario, specimens are only slightly darker than New England examples. In northwestern Ohio and Michigan, however, specimens are noticeably darker and form the transition with *Passerculus sandwichensis oblitus* which breeds from the north shore of Lake Superior (including Isle Royale) northward and north-westward. West of Ohio and Michigan, Savannah sparrows become paler again and tend to have more slender bills, thus showing an approach to the characters of *nevadensis*. It is of interest to note that relatively the same differences are observable in the juvenals as in the adults from the same regions.

Now arises the question of what to do with these varient populations which in the aggregate make up what has been called *P. s. savanna*. If the birds from Nova Scotia are compared directly with specimens from northwestern Ohio, the difference is so extremely marked that one wonders how anyone can call them the same and still recognize *nevadensis* or *labradorius* as distinct from *savanna*. Therefore, it seems desirable to recognize more than one geographic race here,

but the question is where to draw the lines between them, and having separated them, which to call *P. s. savanna* and which the undescribed form or forms.

Here we come face to face with the disconcerting fact that the breeding range of *typical P. s. savanna* has never been defined. This form was described by Wilson from a migrant female specimen, apparently now not extant,[2] taken at Savannah, Georgia. Since·it now seems likely that any one of several subspecies might be expected to occur at Savannah, Georgia, during migration it is all the more important to know which of these Wilson had in hand when he wrote his description. Fortunately a colored plate[3] accompanied this description. The plate depicts a rather pale Savannah sparrow with brown markings distinctly rufescent, and in all ways definitely more like the Nova Scotia bird than any other that the writer has examined. Therefore, it seems that birds from that region should be taken as representing typical *Passerculus sandwichensis savanna*, 42 breeding specimens and numerous migrants of which have been available for study in the Cleveland Museum of Natural History's large Nova Scotia Collection. Two late summer birds from the Magdalen Islands agree rather closely with Nova Scotia specimens and are definitely referable to *P. s. savanna*. Numerous migrant specimens from the Atlantic coast region as well as scattered examples from as far west as Ohio and Mississippi also should be referred to the Nova Scotia form.

Going westward from Nova Scotia a rather abrupt change occurs in the coloration of breeding Savannah sparrows, birds from New England being distinctly darker and more grayish. In going further westward this condition is progressively intensified culminating in the rather dark birds of Michigan and northwestern Ohio.

It seems to the writer that Nova Scotia and Magdalen Island birds are distinct enough from those breeding in New England, whence a series of 10 specimens from Maine, New Hampshire, and Massachusetts have been seen, to be separated from them subspecifically. The writer was also at first inclined to consider the northwestern Ohio and Michigan population a distinct race from the New England birds. However, in view of the fact that whereas the Nova Scotia series is at the

[2]Hellmayr.   Field Mus. Nat. Hist. Zool. Ser., Vol. 13, Pt. 11, 1938, p. 486.

[3]Wilson.   Amer. Orn., Vol. 3, 1811, p. 55 (pl. 22, fig. 3).

extreme end of a progressive chain of character variation (from pale brown to dark gray), the northwestern Ohio and Michigan series present characters that are intermediate between the medium gray New England series and that from Fort Churchill, Manitoba, the type locality of the blackish *P. s. oblitus*. In view of these facts it seems better to recognize only two subspecies instead of three, one in Nova Scotia and vicinity already shown to be typical *P. s. savanna* and one from New England west to the Great Plains with average characters probably presented by breeding populations in northeastern Ohio, northern Pennsylvania and western New York.

Before giving it a name, however, it is of course necessary to consider the applicability of *Passerculus sandwichensis bradburyi*, the name given by Figgins[4] to migrant Savannah sparrows taken at James Island, South Carolina. Mr. Alfred M. Bailey, of the Colorado Museum of Natural History, very kindly loaned the type of *bradburyi* together with ten other specimens from James Island used by Figgins in the description of this race. The type of *bradburyi* is one of only two specimens of the entire series *not* referable to the pale brownish Nova Scotia race that is now known to be typical *P. s. savanna*. The type and one other specimen are much darker and apparently referable to *labradorius*, which name stands by right of priority. Therefore, the medium gray southeastern Savannah sparrow definitely seems to be without a name. The writer proposes to call it:

Passerculus sandwichensis mediogriseus, subsp. nov.

SOUTHEASTERN SAVANNAH SPARROW

Subspecific Characters—Similar to *Passerculus sandwichensis savanna* but darker and more grayish (less brownish) above; streaking on underparts coarser and more blackish. Sides of head less buffy (more grayish); stripe over eye duller or more greenish yellow. Similar also to *Passerculus sandwichensis oblitus* but paler and duller (less contrastingly marked) above; streaking on underparts finer.

Measurements—Adult male (23 breeding specimens from northern Ohio); wing, 66.5–71.5 (average 69) mm.; tail, 45–52.5 (49.6); exposed culmen, 10–12 (11.1); height of bill at base, 6–7.5 (6.6); tarsus, 19–21 (19.5). Adult female (5 breeding specimens from northern Ohio); wing, 63.5–71.5 (average 66.3) mm.; tail, 42–51.5 (46.3); exposed culmen, 10.5–11.5 (11); height of bill at base, 6–7.5 (6.7); tarsus, 19–20 (19.3).

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[4]Proc. Colorado Mus. Nat. Hist., Vol. 2, No. 1, 1918, pp. 2–3.

Type—Adult male, No. 29171, Cleveland Museum of Natural History; Andover, Ashtabula County, Ohio, June 22, 1931; Omar E. Mueller and John W. Aldrich, original number 1243.

Geographic Distribution—Breeds from the Gaspé Peninsula south (excluding Nova Scotia) to New England and New Jersey west to Minnesota and Iowa. South in winter to southeastern United States.

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The rather abrupt transition that is found in northern Ohio from typical *mediogriseus* conditions of the eastern section (Ashtabula, Carroll, Geauga, Portage, and Cuyahoga counties) to a strong infiltration of *oblitus* characters in the northwestern section (Erie, Lucas, and Paulding counties) is very likely due to the origin of the breeding populations in these two sections. There is rather conclusive evidence that the Savannah sparrow entered Ohio as a breeding bird at least in the northwestern section in comparatively recent times.[5] The source of immigrants into the northwestern section would naturally be from regions to the north in Michigan where one finds an approach to *oblitus* characters, while birds entering the northeastern portions of the state would most likely come in along the Lake Erie shore from the northeast through western New York and northern Pennsylvania where conditions more typical of *mediogriseus* prevail.

Specimens from northern Illinois and southern Wisconsin are slightly paler and have more slender bills than typical *mediogriseus*, but are decidedly closer to that race than to *nevadensis*.

The western limit of the range of *mediogriseus* apparently is the eastern edge of the Great Plains grassland climax in Minnesota and Iowa, while its northern limit corresponds roughly with the southern limit of the spruce-fir association from the north shore of Lake Superior through central Ontario and Quebec to the north shore of the Gulf of St. Lawrence.

A very unsatisfactory condition exists in our knowledge of the way in which *P. s. labradorius* intergrades with *P. s. oblitus* because of the paucity of material from the interior of northeastern Canada. Peters and Griscom[6] extend the range of *oblitus* as far east as Lake St. John, Quebec. A single breeding specimen marked merely "Ungava" in the collection of the

[5]Campbell. Wilson Bull., Vol. 40, 1928, pp. 223–225.

[6]Bull. Mus. Comp. Zool., Vol. 80, No. 13, 1938, pp. 445–481.

United States National Museum seems definitely referable to *labradorius*. The area of intergradation is undoubtedly a broad one as is the case between *mediogriseus, oblitus*, and *nevadensis*. But that *labradorius* extends its range farther west than the coast of Labrador and the north shore of the Gulf of St. Lawrence seems almost certain in view of the presence of the substantial number of migrant specimens of definitely *labradorius* affinities from the interior regions: James Bay, Sept. 14; Ontario (Lae Seut, Sept. 19; Agawa Bay, Sept. 12; and Pt. Pelee, Sept. 16 and 17); Michigan (Portage Lake, Sept. 2; Charity Islands, Sept. 13; Wayne County, May 6; and Huron County, May 24); as well as the Ohio localities listed beyond.

Identification of Ohio migrants—In light of the above outlined facts relating to the geographic variation of the Savannah sparrow in eastern North America the collection of 75 migrant specimens assembled from Ohio has been identified as follows:

P. s. labradorius.

 Lucas County, Waterville Township— ♀ im. Sept. 12, 1936
                   Ohio State Museum
 Ottawa " Bay Point   — Sept. 23, 1931
            Cleveland Museum of Natural History
 Cuyahoga " Strongsville Township ♀ Oct. 5, 1935
            Cleveland Museum of Natural History
 Hamilton " Ross Lake   ♂ April 14, 1880
           Cincinnati Society of Natural History

P. s. savanna.

 Lake County, Mentor Headlands ♂ April 20, 1931
            Cleveland Museum of Natural History
 Delaware " Delaware   ♂ March 30, 1932
            Cleveland Museum of Natural History
 Clermont " Union Township ♂ Oct. 25, 1936
            Cleveland Museum of Natural History
 Scioto   " Buena Vista ♀ May 2, 1925
            Cleveland Museum of Natural History

P. s. mediogriseus.

 35 specimens taken in March, April and early May from all sections of Ohio.
 19 specimens taken in September, October and November from all sections of Ohio.

P. s. oblitus.

 Lucas County, Jerusalem Township —♂ May 10, 1936
                 Ohio State Museum
 Lucas   "   " " ♀ May 26, 1939
            Cleveland Museum of Natural History

Ottawa	County, Bay Point	♀	May 18, 1926
		Cleveland Museum of Natural History	
"	" " "	♂	May 18, 1931
		Cleveland Museum of Natural History	
Lake	" Richmond	♀	May 3, 1938
		Cleveland Museum of Natural History	
"	" "	♂	May 3, 1938
		Cleveland Museum of Natural History	
Mercer	" Grand Reservoir	♂	Oct. 19, 1911
		Ohio State Museum	
Clermont	" Union Township	—	April 1, 1934
		Ohio State Museum	
"	" " "	♂	March 26, 1938
		Cleveland Museum of Natural History	
"	" " "	♂	March 26, 1938
		Cleveland Museum of Natural History	
"	" " "	♀	May 12, 1939
		Cleveland Museum of Natural History	
"	" " "	♂	Oct. 27, 1935
		Cincinnati Society of Natural History	
Pike	" Waverly	♂	May 5, 1899
		Ohio State Museum	
Scioto	" Lucasville	♂	May 6, 1925
		Cleveland Museum of Natural History	

P. s. nevadensis.

Clermont	County, Union Township	♂	March 19, 1936
		Cincinnati Society of Natural History	
"	" " "	♂	April 14, 1936
		Cleveland Museum of Natural History	
"	" " "	♂	April 10, 1938
		Cleveland Museum of Natural History	

This sample of migrant birds from Ohio probably gives a fairly good picture of the proportions in which different races mingle during migration just west of the Appalachian Mountains and south of Lake Erie.

A large proportion of the specimens identified as *mediogriseus* showed definite indication of approach to *oblitus* characters as would be expected since this is the case among breeding birds in northwestern Ohio and northwestward to the south shore of Lake Superior. The majority of the migrant specimens, however, seemed fairly typical of the somewhat paler northeastern Ohio or New England type. This fact, together with the finding of four migrant specimens of *savanna* in Ohio, indicates a westward drift to the migration of eastern breeding populations, while the discovery of the three specimens of *nevadensis* in extreme southwestern Ohio (Clermont County) indicates that during migration this form may move somewhat eastward from its breeding range.

In general the northward migration of *P. s. oblitus* is later than that of *mediogriseus*, the bulk of the more northern breeding birds apparently going through Ohio in May rather than April. A few late stragglers of *oblitus* even linger as late as the last week in May as is evidenced by the capture of a perfectly typical female specimen of that form in unworn plumage and with undeveloped gonads in Lucas County on May 26.

The present study was greatly aided by the excellent revisional paper on the Savannah sparrows by Peters and Griscom mentioned above. But even with the use of that very helpful treatise, completion of the task would have been impossible without the aid of a rather large amount of comparative material courteously supplied from various collections. The writer wishes to express his thanks for the loan of this material to the United States National Museum, the United States Biological Survey, the Museum of Comparative Zoology, the Museum of Zoology at the University of Michigan, the Field Museum of Natural History, the Ohio State Museum, the Cincinnati Society of Natural History, the Colorado Museum of Natural History, and the National Museum of Canada, and the private collection of Dr. Lawrence E. Hicks. For helpful advice particularly in respect to the establishment of typical *P. s. savanna* by means of Wilson's plate the writer is indebted to Dr. Harry C. Oberholser.

Perspectives in Biochemistry

Many of the most fascinating frontiers of present day science are found in the field of biochemistry. Rapid progress has recently been made in our knowledge of protein chemistry, the nature of viruses and hormones, the chemistry of genetic variations in certain flower pigments, the role of vitamins, the action of drugs on the nervous system, and various other aspects of biochemistry. The recent book, Perspectives in Biochemistry, contains thirty-one essays by authorities in biochemistry and related fields. The essays are presented with unusual simplicity and are arranged in consistent order. A bibliography is included at the end of each chapter. Each of the topics is of general interest, as indicated by the following samples: The Biochemistry of the Individual, The Meaninglessness of the Terms Life and Living, The Economy of the Bacterial Cell, The Chemical Regulation of Insect Growth, The Biochemistry of Flower Color Variation, Biochemistry and Mental Disorder, Drugs and Mankind, The Social Implications of Biochemistry. On reading this book one appreciates more fully the interdependence of the various branches of science. Thus biochemistry is closely allied with organic chemistry, phsyiology, genetics, physics and bacteriology. Perspective in Biochemistry should be available to all those wishing to keep abreast of the march of science, whether scientific laymen or workers in other fields of science.—*D. C. Rife.*

Perspectives in Biochemistry, edited by Joseph Needham and David E. Green. xxxi+361 pp. Cambridge at the University Press, New York, the Macmillan Co. 1938. $4.75.

A STUDY OF THE EFFECTS OF INCREASED IODINE FEEDING TO A HERD OF SIXTY DAIRY COWS[1]

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It is the purpose of this paper to present the results obtained in an experiment designed to determine the effects of increased iodine feeding upon a herd of sixty dairy cows. The great number of variable factors encountered, however, prevent the drawing of any final or even of comprehensive conclusions; even from the extensive data collected.

We endeavored to conduct this experiment in as scientific a manner as possible, without too greatly disturbing the routine of the dairy. The farm employees were carefully instructed and trained in the collection of specimens. The best quantitative methods available were used. Nevertheless, it must be borne in mind that such a study as this, even at its best, cannot possibly be as accurate as an investigation using laboratory animals, or even human beings under controlled hospital conditions.

The valuable herd of dairy cows used in this experiment produces *a Grade A raw milk*, which is delivered in Columbus, Ohio.[4] It was therefore necessary to protect this privately owned dairy herd by carefully observing the cows during the entire experiment. The general health of the cows, the output of milk and the quality of milk were essential factors to be conserved. The cows had been previously tested for tuberculosis, B-abortus and mastitis.

LITERATURE

A brief review of the literature is first presented in order to consider the various effects of increased iodine feeding which have been thus far reported. Several investigators have previously used both laboratory and domestic animals, as well as hospital patients.

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Marine (1) as early as 1907 stated that iodine-containing salts had been fed to Michigan sheep to prevent the high death rate ordinarily then occurring among the new-born. Ten years later Smith (2) observed the abnormal condition which he called "Fetal Athyreosis." This state in new-born pigs is characterized by an enlarged thyroid gland, thickened skin, hairlessness or weakness, and often by still-birth. Smith estimated that as many as 10,000 animals were lost annually in Montana. Kalkus (3) reported a high incidence of "Fetal Athyreosis" in horses, cattle, sheep and goats. Furthermore, breeding difficulties have also been described in pigs of North Dakota (4) and Wisconsin (5), and similar observations have been made elsewhere (6) (7).

Hanzlik (8) showed that supplemental iodine feeding is a factor in the rate of growth of laboratory animals. He observed, moreover, that rats having a diet rich in iodine maintain a better general condition than those without such a supplement.

Evvard and Culbertson (9) observed an increase in the rate of growth of domestic animals subsequent to the addition of iodine to the diet. They fed 5 milligrams, 43 milligrams and 55 milligrams of potassium iodide per day to a total of 36 pigs. The increase in the rate of growth averaged ten per cent for all the pigs even though they ate ten per cent less food. Kelly (10) reported similar results in the growth of young pigs. Weiser and Zaitschek (11) studied the size of the litter and the weight of the offspring. They fed 125 milligrams of potassium iodide per day to sows during the last three weeks of gestation and the first ten weeks of lactation. Of the non-iodized group 3.8 pigs per litter were raised whose average weight at the end of ten weeks of lactation was 13.2 kilograms. Of the iodized group 7.6 pigs per litter were raised whose average weight was 18.5 kilograms. Other investigators (12) (13) found no essential differences in the weights of pigs fed amounts of potassium iodide varying up to one gram.

The effect of increased iodine feeding upon the milk production of cows was studied by Stiner (14), Scharrer (15), Weiser and Zaitschek (11) and Thomson (16). Stiner in 1924 observed that the addition of iodine to the diet of cows resulted in an increase of milk production over controls. Scharrer and his group increased the milk yield 5–10 per cent by adding large quantities of iodine, 100 to 600 milligrams per day, to the diet of the cows. Weiser and Zaitschek obtained a seven per cent

increase in milk production by feeding 125 milligrams of potassium iodide per day.

More recently Thomson (16) made a comparative study on Ayrshire cows over a period of five years. He used eight cows as controls and fed seven cows 90 milligrams of iodine per day. For the five-year period the non-iodized group produced 788 gallons of milk per cow per year while the iodized group produced only 747 gallons per year. However, a comparison of these values with those of the first year, in which the non-iodized cows produced 749 gallons and the iodized cows 626 gallons, show that the iodized cows registered larger gains. Thomson did not attempt to draw any significant conclusions from this extensive study.

The normal iodine content of cows' milk has been determined by numerous investigators. The average iodine content of milk in goitrous areas is 2.9 mcg. per cent,[5] but this result is based upon a limited number of determinations (17). Hanford, Supplee and Wilson (18) obtained average values of 6.9 in South Carolina, 3.2 in Wisconsin and 2.7 mcg. per cent in New York.

European investigators, as well as investigators in our own country, have studied the milk iodine values of cows receiving increased iodine feeding. Scharrer and Schwaibold (19) obtained milk with only 28.9 mcg. per cent iodine from cows fed 100 milligrams per day, 37 mcg. per cent for 200 milligrams fed per day, and 212 mcg. per cent for 600 milligrams fed per day. Hanford, Supplee and Wilson (18) found 25, 40.3 and 181.3 mcg. per cent on feeding 3.1, 46. 3 and 198 milligrams per day, respectively. The milk iodine of the control cows was 6.1 mcg. per cent. Orr and Leitch (20) obtained 33 mcg. per cent by feeding 180 milligrams per day whereas they obtained only 4 to 7 mcg. per cent for their control cows. McHargue (21) elevated the iodine in milk to 40 mcg. per cent by feeding iodine.

Other European investigators (22) (23) (24) have shown that the iodine content of milk from cows and milking goats increases following increased iodine feeding. None of the above investigators reports any deleterious effects from the increased iodine intake.

A previous investigation made within our group (25), using a herd of Brown Swiss Cows, showed that upon the addition of approximately 94 milligrams of iodine per day the iodine content of the milk was found to vary from 0.016 to 0.182 mcgm. per

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[5]This represents 29 parts of iodine per billion of milk.

cent, which is a great increase over the normal milk iodine. A definite increase in blood iodine, urinary excreted iodine and fecal iodine was also observed. Since, however, no control cows were available, a comparative study was impossible.

METHODS

Two breeds of cows, Holstein and Guernsey, numbering 30 each, were used in this experiment. These cows were kept in their normal environment. A study of the cows was made during the Fall of 1935 and the Winter, Spring and Summer of 1936. The major portion of the study was conducted during the colder months, November to April, when the cows were kept under shelter. Later, observations were made when the cows were turned out to pasture.

Before any increased iodine feeding was instituted, it was found desirable to obtain a rough idea as to the status of the normal iodine "balance" of the cows to be studied. Blood was obtained by vena puncture from each of the sixty cows on November 19, 1935, for the determination of iodine. On December 14 to 15, 1935, and on February 15 to 16, 1936, two one-day "balance" studies were made. Representative samples for the determination of the iodine content of the feed intake (water, ensilage, alfalfa hay and a grain mix) were also obtained and analyzed.

Since the collection of specimens for the determination of iodine in the excreta required a constant attendant, only six Holstein and six Guernsey cows were studied. These were chosen at random, to represent their respective groups. Great care was exercised to obtain and record all the excreta for the 24-hour period. A representative sample of the pooled specimens of urine and feces was taken for analysis. The amount of milk yielded in the 24-hour period was carefully recorded and a composite sample of the two milkings (3:00–5:00 A. M. and 2:00–4:00 P. M.) was taken for analysis.

On February 16, 1936, the Holstein and Guernsey groups of cows were divided into two groups, each composed of 15 cows. From this time on 15 Holstein and 15 Guernsey cows were fed continually a grain mixture which contained by actual analysis 3.2 milligrams of iodine per 100 grams of feed. The Ubiko Milling Company of Cincinnati, Ohio,[6] furnished this iodized

mixture, a feed prepared as one-twenty-thousandth potassium iodide or 3.4 milligrams of iodine per 100 grams of feed. Calculations show that the iodized Holstein cows received an average of 131 mg. of iodine and the iodized Guernsey cows an average of 95 mg. of iodine per day throughout the year.

The uniodized grain mixture which was fed to the control group was obtained from the same company. This feed was essentially the same as that which had been fed both groups from December 4, 1935, to February 16, 1936.

It was expedient to duplicate the "balance" studies as of the first part of the experiment previous to the institution of increased iodine feeding. Therefore, on April 14, 1936, blood samples were again obtained from all the cows. Milk samples were obtained which were representative of the 24-hour secretion on April 17 to 18, 1936.

The third "balance" study was made on three cows for each of the four groups (non-iodized Holstein and Guernsey and iodized Holstein and Guernsey). This "balance" study was conducted as was the experiment before iodinization. From the iodized cows of both breeds, for a period of five months (June to October, 1936), composite samples of milk were obtained three mornings a week for iodine analysis.[7]

All the specimens were analyzed for iodine by means of the Matthews, Curtis and Brode method (26). This method has been carefully tested, and yields results precise to 5 per cent under ideal conditions.

The official dairy tester measured the amounts of feed that the cows were receiving on April 16, May 22, June 12, July 17, August 26, September 18 and October 15, 1936. From these measurements the average amounts of iodine received by both the Guernsey and Holstein cows in the grain mixture were calculated for these dates as 128, 67, 82, 113, 125, 120 and 118 milligrams per day, respectively.

<div align="center">RESULTS</div>

The results of this experiment are best presented in table form. For convenience the non-iodized cows have been called Group I and the iodized cows Group II.

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[7]The results of feeding of the iodized milk to hospital patients will be reported in a subsequent publication.

Table I presents the blood iodine values in November before supplemental iodine feeding was instituted, and in April after iodinization. Figure 1 illustrates graphically the marked elevation of the blood iodine subsequent to the increased iodine intake.

The results of the one-day "balance" studies are presented as averages and are as accurate estimations as possible. The data obtained in the three "balance" studies are shown in Table II for each of the individual cows. Table III presents the group averages of the "balance" studies which are graphically presented in Figure II.

TABLE I

BLOOD IODINE VALUES

Time of Test	Breed of Cow	Group	Number of Cows Tested	Average Amount of Iodine (in mcg.) in 100 cc. of Blood	Mean Deviation from Average
Nov., 1935	Holstein	I & II	26	4.02	.95
Nov., 1935	Guernsey	I & II	27	3.82	.77
April, 1936	Holstein	I	14	4.85	1.24
April, 1936	Holstein	II	13	57.10	12.10
April, 1936	Guernsey	I	8	6.25	2.4
April, 1936	Guernsey	II	10	55.60	9.2

The blood iodine values of the non-iodized Holstein and Guernsey cows in November, 1935, and of the iodized and non-iodized cows of both groups in April, 1936.

An attempt was made to determine whether the iodine in the iodized milk was in fat or protein combination. The fat was removed by the Rose-Gottlieb (27) method and the protein by the method of Osborne and Mendel (28). From 80 to 90 per cent of the iodine remained after removal of the fat and protein. In this respect our observations confirm those of Scharrer and Schwaibold (19), who likewise studied milk from cows fed relatively large amounts of potassium iodide. They, too, found little iodine in protein or fat combination.

Other data pertaining to milk and butter-fat production, calf records, general health of the normal control cows and iodized cows will be presented by Professor O. Erf, who has collaborated in this work.
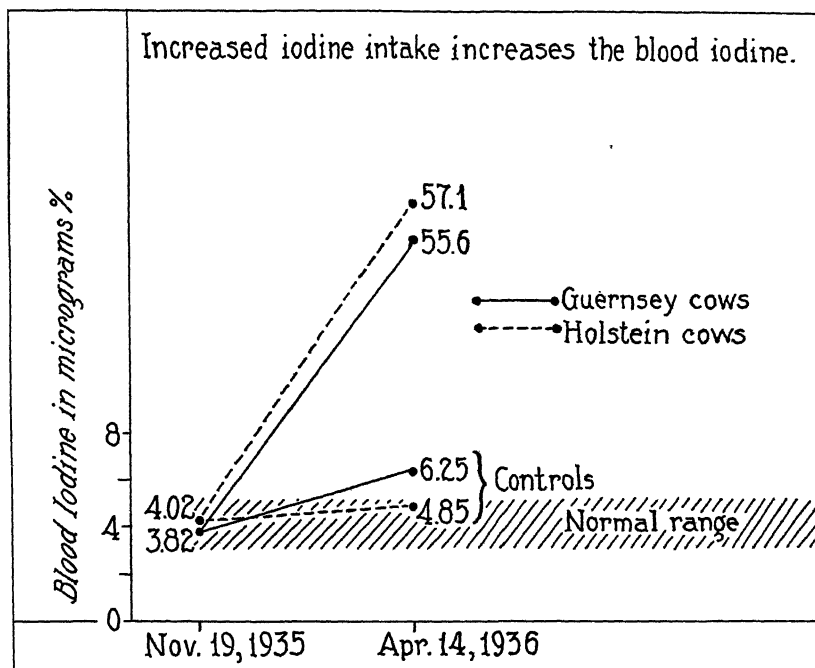
FIG. 1. Marked elevation of the blood iodine subsequent to increased iodine intake by the Holstein and Guernsey cows.

ONE DAY "BALANCE" STUDY ON HOLSTEIN AND GUERNSEY COWS.
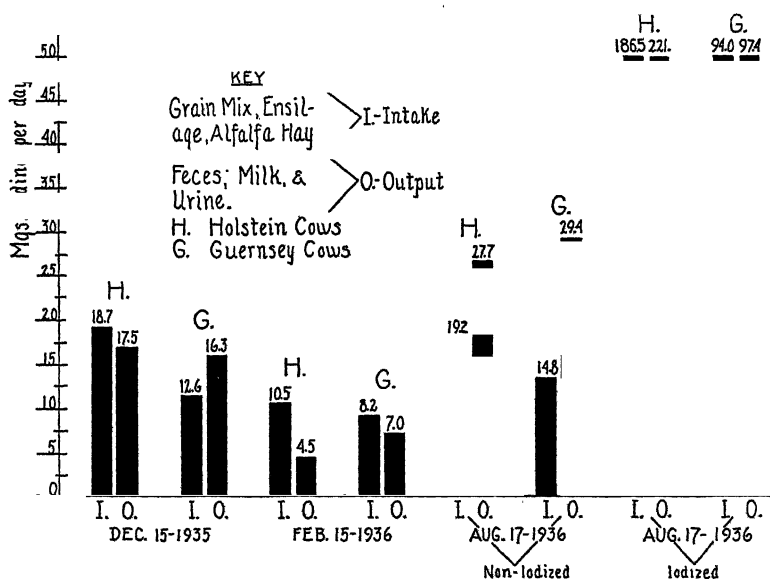
FIG. 2. A comparison of the average intake and output of iodine for iodized and non-iodized Holstein and Guernsey cows on December 15, 1935, February 15, 1936, and August 17, 1936.

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TABLE II

Metabolism Studies of Cows

Date	The Number of the Cows	Breed	Estimated Food Intake Per Day							Estimated Iodine Excretion Per Day							
			Alfalfa Hay		Ensilage		Grain Mix		Total Iodine Intake mg.	Urine		Milk		Feces		Total Iodine Excretion mg.	Balance mg.
			Weight kg.	Iodine Content mg.	Weight kg.	Iodine Content mg.	Weight kg.	Iodine Content mg.		Volume liters	Iodine Content mg.	Volume liters	Iodine Content mg.	Weight kg.	Iodine Content mg.		
December 14–15, 1935	56	Holstein	7.3	2.3	15	8.0	5.5	10.2	20	8.6	2.4	19.0	2.6	45	13.0	18	+2
	57	"	7.3	2.3	15	8.0	4.1	7.7	18	8.6	2.4	6.6	1.9	27	8.0	12	+6
	59	"	7.3	2.3	15	8.0	4.5	8.5	19	9.1	2.4	8.1	4.4	41	16.0	23	−4
	1	"	7.3	2.3	15	8.0	4.5	8.5	19	5.9	1.8	16.0	3.0	27	6.5	11	+8
	3	"	7.3	2.3	15	8.0	3.6	6.8	17	8.2	3.7	13.0	2.8	35	17.0	24	−7
	5	"	7.3	2.3	15	8.0	4.5	8.5	19	5.7	1.6	15.0	1.7	37	13.0	16	+3
	17	Guernsey	5.5	1.7	12	6.2	2.7	5.1	13	8.2	9.8	8.3	2.1	28	15.0	27	−14
	18	"	5.5	1.7	12	6.2	2.7	5.1	13	6.4	2.9	4.5		23	4.9	8	+5
	19	"	5.5	1.7	12	6.2	2.7	5.1	13	6.4	6.7	4.9	.6	20	9.2	17	−4
	42	"	5.5	1.7	12	6.2	2.3	4.3	12	7.3	3.3	1.3	1.5	27	8.7	12	−0
	43	"	5.5	1.7	12	6.2	2.3	4.3	12	9.5	7.5	4.1	.6	26	10.0	18	−6
	45	"	5.5	1.7	12	6.2	2.3	4.3	12	8.2	4.6	5.4	1.5	21	8.6	15	−3
February 15–16, 1936	56	Holstein	7.5	6.0	15	3.6	5.6	1.4	11	7.8	1.3	14.0	.3	30	2.7	4.3	+7
	57	"	7.5	6.0	15	3.6	1.9	.5	10	4.7	.7	3.3	.1	14	3.4	4.2	+6
	59	"	7.5	6.0	15	3.6	1.9	.5	10	6.9	1.0	3.1	.1	29	3.5	4.6	+5
	1	"	7.5	6.0	15	3.6	3.8	1.0	11	5.1	.7	15.0	.4	27	4.9	6.0	+5
	3	"	7.5	6.0	15	3.6	2.8	.7	10	1.8	.4	8.3	.4	23	3.4	4.2	+6
	5	"	7.5	6.0	15	3.6	4.7	1.2	11	4.1		13.0	.5	30	4.2	5.2	+6
	43	Guernsey	5.6	4.5	12	2.9	4.7	1.2	9	12.0	4.5	12.0	.3	15	3.4	8.4	+1
	44	"	5.6	4.5	12	2.9	3.8	1.0	8	2.1	.2	11.0		22	8.9	9.4	−1
	45	"	5.6	4.5	12	2.9	3.3	.8	8	5.0		9.1		22	2.5	3.3	+5
	17	"	5.6	4.5	12	2.9	2.3	.6	8	3.6	1.6	6.4	1.2	15	5.7	8.5	−1
	19	"	5.6	4.5	12	2.9	1.9	.5	8	3.4	.4	3.6	.5	11	3.3	4.2	+4
	20	"	5.5	4.5	12	2.9			7		.7			17			−1

TABLE II—(Continued)

METABOLISM STUDIES OF COWS

Date	The Number of the Cows	Breed	Estimated Food Intake Per Day								Estimated Iodine Excretion Per Day							
			Alfalfa Hay		Ensilage		Grain Mix		Total Iodine Intake mg.	Urine		Milk		Feces		Total Iodine Excretion mg.	Balance mg.
			Weight kg.	Iodine Content mg.	Weight kg.	Iodine Content mg.	Weight kg.	Iodine Content mg.		Volume liters	Iodine Content mg.	Volume liters	Iodine Content mg.	Weight kg.	Iodine Content mg.		
August 17–18, 1936	56	Holstein	12.0	6.7	20.0	2.2	8.0	7.7	16.3	8.2	3.7	5.1	1.2	40	27.0	32	—20
	57	"	12.0	6.7	20.0	2.2	12.0	11.6	20.3	13.0	.7	21.0	5.3	38	15.0	21	—2
	58	"	12.0	6.7	20.0	2.2	12.0	11.6	20.3	20.0	5.0	11.0	4.3	40	22.0	31	—14
	2	"	12.0	6.7	20.0	2.2	10.0	145.0	154.0	16.0	61.0	13.0	18.0	37	94.0	173	—52
	4	"	12.0	6.7	20.0	2.2	14.0	210.0	219.0	14.0	66.0	27.0	74.0	50	157.0	297	—116
	8	"	12.0	6.7	20.0	2.2	12.0	175.0	184.0	11.0	56.0	24.0	49.0	46	87.0	192	—11
	43	Guernsey	9.3	5.5	15.0	1.6	8.0	7.7	14.8	15.0	10.0	9.5	1.0	23	9.0	20	7
	44	"	9.3	5.5	15.0	1.6	8.0	7.7	14.8	10.0	40.0	4.0	.4	25	9.0	49	—37
	45	"	9.3	5.5	15.0	1.6	8.0	7.7	14.8	13.0	5.0	9.2	2.0	23	12.0	19	7
	16	"	15.0	5.5	15.0	1.6	6.0	87.0	95.0	8.2	29.0	9.7	10.0	29	79.0	118	—27
	17	"	15.0	5.5	15.0	1.6	4.0	58.0	85.0	12.0	5.0	1.0	.8	16	33.0	39	+40
	18	"	15.0	5.5	15.0	1.6	8.0	116.0	123.0	15.0	50.0	4.4	5.5	32	81.0	137	—29

The intake and output of iodine of Holstein and Guernsey cows, iodized and non-iodized, on December 14-15, 1935, February 15-16, 1936, and August 17-18, 1936.

TABLE III

"BALANCE" STUDIES ON THE GROUPS OF COWS

| DATE	No. of Cows	BREED	MGS. OF IODINE INGESTED PER DAY (Averages)				MGS. OF IODINE EXCRETED PER DAY (Averages)			
			Alfalfa Hay	Ensilage	Grain Mix	Total	Urine	Milk	Feces	Total
12-15-35	6	Holstein	2.3	8.0	8.4	18.7	2.4	2.7	12.4	17.5
12-15-35	6	Guernsey	1.7	6.2	4.7	12.6	5.8	1.1	9.4	16.3
2-15-36	6	Holstein	6.0	3.6	0.9	10.5	0.8	0.3	3.4	4.5
2-15-36	6	Guernsey	4.5	2.9	0.8	8.2	1.3	0.5	5.2	7.0
8-17-36	3	Holstein	6.7	2.2	10.3	19.2	3.1	3.4	21.0	27.7
8-17-36	3	Holstein	6.7	2.2	176.6	186.5	61.0	47.0	113.0	221.0
8-17-36	3	Guernsey	5.5	1.6	7.7	14.8	18.3	1.1	10.0	29.4
8-17-36	3	Guernsey	5.9	1.6	87.0	94.0	28.0	5.4	64.0	97.4

The average intake and output of iodine of non-iodized and iodized Holstein and Guernsey cows on December 15, 1935, January 15, 1936, and August 17, 1936.

DISCUSSION

The determination of the blood iodine of the normal cows by the Matthews, Curtis and Brode method (26) yields iodine values which approximate our values obtained for human blood by the same method. Previous to this study blood iodine values obtained by numerous investigators were, with one or two exceptions, at a much higher level. Other investigators (29) (30) (31) present values which confirm the more recent lower level. In the hands of experienced workers the newer methods have yielded iodine values which are comparable to the values obtained in this study.

The blood iodine values for the Holstein cows previous to increased iodine feeding averaged 4.02 mcg. per 100 cubic centimeters of blood, while those of the Guernsey cows averaged 3.82 mcg. per 100 cubic centimeters of blood. This slight difference is probably not significant. In the April study the blood iodine values of the non-iodized cows were higher than in the November study. These higher values may be due to a slight contamination of the feed or to a seasonal variation; on the other hand, they may not be significantly different from those obtained in November in view of the large average mean

deviations and the smaller numbers of non-iodized cows in April, one-half those in November.

The blood iodine values of the iodized cows were approximately ten times higher than those of the non-iodized cows. The increase in the amount of iodine in the blood of iodized cows with respect to the non-iodized cows of both groups in November is of the order of 1300 per cent and approximately the same for the Holstein and Guernsey cows. With respect to Group I in April, the per cent increase is of the order of 1000. This illustrates the effectiveness of the amount of iodine being fed in reaching the blood stream, and consequently in maintaining a much higher level of available iodine for utilization by the body.

In a former study within our group the blood iodine of the iodized cows averaged 54.9 mcg. per 100 cubic centimeters of blood, a value comparable with values obtained in this study; 55.6 mcg. per cent for Guernsey and 57.1 mcg. per cent for the Holstein cows.

During the month of April the milk iodine reflected to a greater degree than the blood iodine the different levels of iodine fed to the two groups.

The data of the "balance" studies is only approximate, since accurate estimations of food intake, the obtaining of representative samples of food for analysis and the collection of excreta were difficult. The amount of iodine ingested in the water was considered negligible since the iodine content of the water was found to be only 0.5 mcg. per cent.

The December "Balance" Study

In the December study the six Holstein and the six Guernsey cows were nearly in balance. The average iodine intake for the Holstein cows, the greater part of which was found in the grain mixture, was 18.7 milligrams per day. The average output was 17.5 milligrams per day, which is only 1.2 milligrams below the intake. The greatest channel of excretion was the feces. The Guernsey cows during the same period were also nearly in balance. The average iodine intake of 12.6 mg. was below that of the Holstein cows. The output of 16.3 milligrams per day was lower than the output recorded by the Holstein cows, being 17.5, and only 3.7 milligrams per day above the intake. Here again the largest amount of iodine was excreted by way of the feces. Both the Holstein and Guernsey cows received most of their iodine from the ensilage and grain mixture.

The February "Balance" Study

In the February study the Holstein cows were in positive balance. The average iodine intake was 10.5 milligrams per day, 6.0 milligrams above the output. The Guernsey cows during this period were approximately in balance, the average iodine intake of 8.2 milligrams per day being 1.2 milligrams per day above the average output of 7.0 milligrams per day.

The February "balance" was on the whole at a lower level than the December "balance"; both the intake and the output of the Holstein and Guernsey cows were on a lower level. Whereas the ensilage and grain mixture each furnished the largest amounts of iodine in December, the alfalfa hay was the chief source in February. The feces, as in the December study, was the largest channel of excretion of iodine.

The August "Balance" Study

The August "balance" study for a period of increased iodine feeding shows a quite different picture. Of both the non-iodized cows and the iodized cows, Guernsey and Holstein, all but one were in negative balance. This negative balance averages 12 milligrams and 17 milligrams per cow, respectively, for the non-iodized Holstein and Guernsey cows of the controls. The non-iodized Holstein cows showed an intake of 19.1 milligrams per day and an output of 27.7 milligrams per day. The non-iodized Guernsey cows were in still greater negative balance, showing an intake of 14.8 milligrams per day and an output of 29.4 milligrams per day. Of the iodized cows the Holstein average intake was 186 milligrams per day and the output 221 milligrams. The iodized Guernsey intake was 94 milligrams per day and the output averaged 97.4 milligrams per day. The ratios of intake to output for the month of August are slightly less than 1.0, in all cases but one, in contrast to the ratios for December and February, which are in general slightly greater than 1.0.

The differences between intake and output are greater for iodized cows and therefore more negative. However, a comparison of ratios will show that it is impossible to say that either the iodized cows or the non-iodized cows were in greater negative balance. It is true, though, that for a greater iodine intake there was a greater output. In actual figures the iodine output of the iodized cows was seven to nine times that of the non-iodized cows in the case of the Holsteins, but only three to four

times in the case of the Guernseys. The feces was again found to be the predominant channel of excretion of iodine for both the Holstein and the Guernsey cows.

The iodine intake of the cows during this period of pasturage varied greatly. The alternating drought and rain varied both the amount of exercise the cows obtained and the amount of food consumed. When pasturage was available, less feed and more grass was consumed. The reverse was true when none was available. Of all the feeds the grain mixture at this time contained the highest concentration of iodine.

The great negative balance of the cows may be due to (1) increased consumption of unaccountable iodine; (2) increased activity of the cows during pasturage; (3) continued excretion of iodine previously ingested in larger amounts.

To explain the great variation of the composite milk samples collected during the mid-year, the following facts must be considered. During the late spring and early summer the pasturage was abundant. Simultaneously iodized cows were fed lesser amounts of grain mixture containing added potassium iodide. In midsummer the grass in the pastures became scarce because of the extensive drought. Beginning late in June the cows were fed larger amounts of grain mixture.

An average analysis of a few grains and hays in goitrous regions yielded a result of 30 mcg. per cent (32). Forbes et al (13) found only 10 mcg. per cent in Pennsylvania. Remington and Supplee (33) found an average of 45 mcg. per cent for hog feed in South Carolina.

Ohio is generally considered to be a goitrous region. Several factors, however, may vary the iodine content of the plants of the pasture. Commercial fertilizer has been shown by investigators (20) to increase the iodine content of plants. Also, the feces of the cows, especially those receiving increased iodine feeding, would be a source of iodine for the plants.

Our determinations in February on the milk iodine values of our control cows were similar to those of other investigators mentioned in the literature. Those in April on the non-iodized cows were slightly higher. Those in December and in August were much higher.

The values of the iodine content of the milk of the iodized cows contrast with those obtained by authors mentioned in the literature. Our values for Holstein and Guernsey cows in April were 203 mcg. and 149 mcg. per cent respectively, and beginning

May 23 they averaged 80 mcg. per cent for the five months midyear (34).

The effectiveness of the use of milk containing increased iodine as a goiter prophylactic has been demonstrated both for man (35) and for experimental animals (36).

SUMMARY

Since this study, unlike our previous investigation, involved a control group of both breeds of cows used, several features of the increased iodine feeding may be noted.

No deleterious effects of the increased iodine feeding were detected. The iodized cows were apparently in as good health as the non-iodized cows.

The iodized cows were found to have blood iodine values ten times that of the control cows, a difference approximately of the order of 1000 per cent. It should be noted that the blood iodine values of the control cows are comparable to the values obtained for normal human blood.

In the "balance" studies an outstanding feature is that increased iodine feeding to dairy cows results in increased iodine content of the milk. Variations, however, do occur in the ratio of iodine in the milk to the total amount of iodine ingested. Where the iodine content ingested is increased tremendously, the increase in iodine in the milk may be even far greater than that expected from the consideration of a direct proportion. The dependence of the amount of iodine in the milk upon the amount of iodine in the food is thus firmly established. The amount of iodine in the milk seems to be independent of the volume of milk produced by the cow.

On high iodine intake the iodine in the milk is much greater than the iodine in the blood; on low iodine intake the iodine in the milk may be below the normal value.

The ratio of iodine intake to output is in all cases approximately equal to 1.0, being greater than 1.0 for the months of December and February and slightly less than 1.0 in August, a month in which the balance was consistently negative. The feces was in all cases the chief channel of excretion of iodine, approximately 70 per cent of the output of iodine being through this channel.

Feeds of the control cows were found to be considerably higher in iodine content than those reported from other goitrous regions. Similarly, milk from these cows was found to contain a larger concentration of iodine.

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Destructive and Useful Insects

Economic entomologists welcome the appearance of the improved and enlarged second edition of "Destructive and Useful Insects" by Metcalf and Flint. Several new features are decided additions to the book, particularly the keys to orders for adults and immature stages of insects. If the keys, especially those to immature stages, prove to be good ones, entomologists in general will be greatly pleased. The authors have also assigned a number to each insect as it is discussed under a given crop. These numbers appear after the name of the insect wherever it is discussed. This makes it possible to locate all of the information in the text on a particular insect without the use of the index. Many changes and improvements have been made on the control recommendations for many of the pests. The book is profusely illustrated. Some of the illustrations show signs of wear. These might have been omitted or improved. The number of pages in the second edition is 981 compared with 918 for the first edition. The authors are to be congratulated on the quality of the book produced. It has been a distinct pleasure to review this most useful book.—*A. Peterson.*

Destructive and Useful Insects, by C. L. Metcalf and W. P. Flint. xii+981 pp. New York, the McGraw-Hill Book Co., 1939. $7.50.

THE STRUCTURE AND THICKNESS OF THE CLINTON AND BEREA FORMATIONS IN THE VICINITY OF WOOSTER, OHIO

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INTRODUCTION AND ACKNOWLEDGMENTS

The data used in the construction of the structure maps were obtained from well records, filed at the field offices of the oil and gas companies operating in the area, and from the Ohio State Geological Survey. The purpose is to give one information on the structure of the Clinton and Berea formations and their thickness throughout the area. With the exception of an earlier report,[1] based on available well records at that time, no other information has been published. Many wells have been drilled since 1915 and more complete information is now available.

The writer acknowledges the aid given by Alan Leeper and George Miner, students in the Department of Geology, who plotted the structure obtained from data based on well records.

THE CLINTON AND BEREA FORMATIONS

The Clinton sand is the horizon from which the oil and gas are produced in largest quantities in the area. This formation is composed of sandstones, shales and interbedded limestone. The color of the Clinton is gray to reddish and the thickness may be as much as 85 feet. To the south this formation is more calcareous; crinoid stems are abundant and there is much resemblance to marble in some localities. The sand from which production is greatest is near the bottom of the group and some geologists consider it a part of the Medina. At several places, stray sands are found just above the Clinton, and are often reported as "red rock." Perhaps this is the bed which thickens to the east and becomes iron ore. To the westward the Clinton thins out and is a shale just beyond the center of Ohio. Here it is a fine-grained deposit which requires that the well be shot in order to obtain any production. In the southern part of Ohio, the Clinton is not a good reservoir and contains more limestone; the sand is more porous in central

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[1]Bonine. Structures in the Clinton Sand. Bull. U. S. G. S. 1915, pp. 89–92.

Ohio and is consequently more productive there.   The com-
position of the Clinton, varying as it does in different areas, has
been a foremost factor in the determination of the oil and gas
fields.   Productive areas occur as far to the northwest as
Sandusky but the best field in the Clinton is in central Ohio.

   The Berea formation is described with the Clinton because
of its importance as a key for that horizon.   The Berea Grit is
of lower Carboniferous age and in the Wooster area lies about
600 feet below the surface.   The Berea underlies more than
one-third of the state, with little variation in its composition.
It is a moderately fine, siliceous sandstone, which is widely
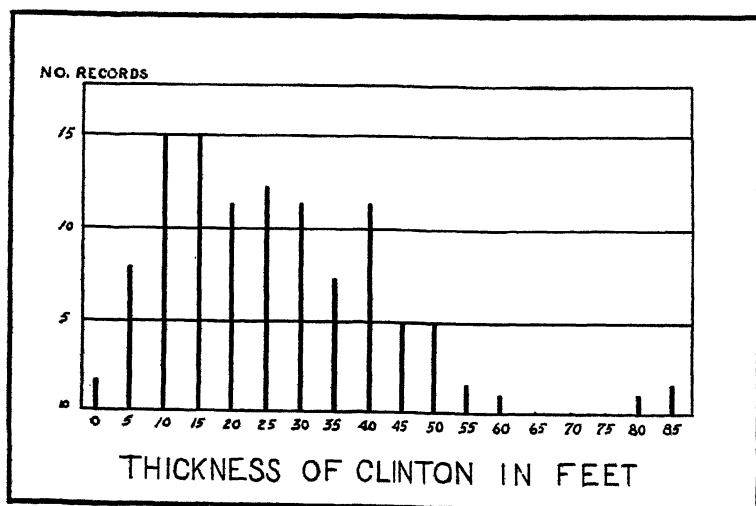
Fig. 1.   Thickness of Clinton in feet.

used as a building stone.   It is important as a reservoir for
oil, gas and salt water.   In the Wooster area, only small
producers of oil and gas are present.   Here it serves as an
important key to the drillers seeking the Clinton.   Although
the Berea does not show as much folding as the Clinton, enough
similarity does exist so that the Clinton structure can be
interpreted by drilling to the Berea.   It averages about 30
feet in thickness, varying from nothing to 150 feet.   It is
medium-grained and gray to buff in color; except for small
areas having a high carbonate of lime content, the composition
is quite uniformly a siliceous sandstone.   The variation in
thickness of the Berea is probably explained by the fact that
it lies on an uneven surface.   The data is from well records in
Wooster, Plain and Franklin Townships, all in Wayne County.

GEOLOGIC STRUCTURE

In the Wooster field, the granite base upon which lie the sedimentary rocks is probably 5,000 or more feet below the surface. The area lies along the east flank of the Cincinnati arch, the strata dipping eastward as much as 50 feet per mile in some places. Erosion has removed most of the Allegheny and Pottsville formations which originally covered the area.

The most important feature of the structure is the cross-folding which has occurred; this is true over nearly all of Ohio. The existing folds are at right angles to each other, having general trends of northeast-southwest and northwest-southeast.
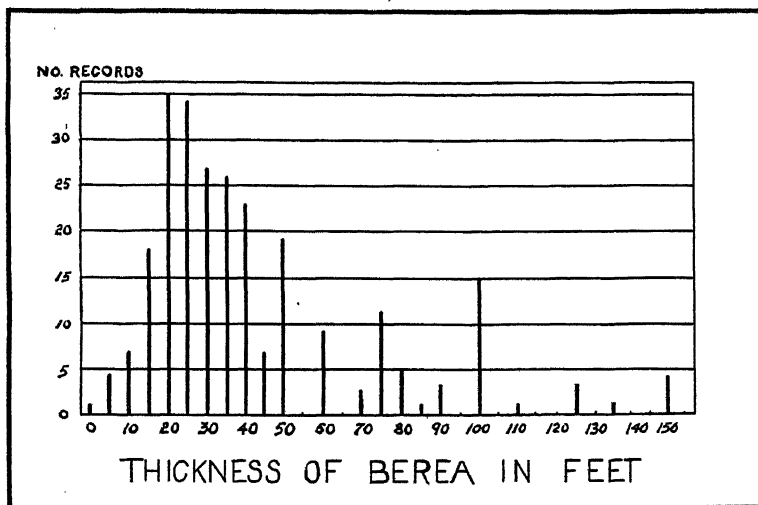
Fig. 2. Thickness of Berea in feet.

It would be a very interesting study to determine the exact nature of the two sets of forces involved in the formation of these anticlines. The folds trending northeast-southwest, in all probability, were developed by the same forces which produced the Appalachian folds. The anticlines of this region represent the gradually declining waves as the forces diminished to the westward. Less is known about the folds trending northwest-southeast, and it is this particular group which would bear more investigation. Both sets of folds occur widely distributed throughout Ohio, and it is possible that other stresses besides those which formed the Appalachians are responsible for the northwest-southeast folds. The existence of the two systems of anticlines complicates the geologic

structure and makes drillers less certain of successful results.
Evidence points to the fact that the Clinton has been folded
more than the Berea, probably because the Clinton was sub-
jected to folding forces before the deposition of the Berea.
Such a high degree of similarity exists in the structure of the
Clinton and Berea, that drillers often use the latter to determine
the structure of the Clinton.   There is a belief by many that
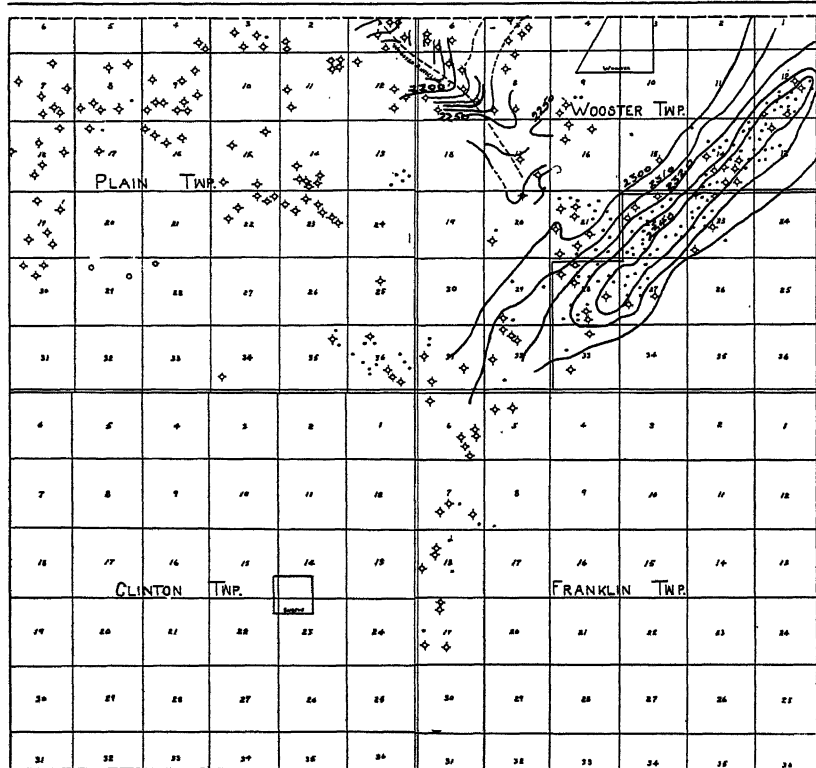
Fig. 3.   Structure of the Clinton sand.   Structural contours indicate the elevation
below sea-level of the Clinton sand.

no relation exists between the folds and the oil and gas pools
in the region.   In the vicinity of Wooster this is not the existing
condition.   Extensive drilling has proved that the production
of a well depends upon its location with respect to geologic
structure.   In the field southwest of Wooster, production
has been best along the axis and flanks of an anticline.   In
supporting the view that structure is most important, one must
consider the numerous pools caused by terrace structure or

"arrested dips," as they are sometimes called. These are the results of a leveling-off of the strata which otherwise dip about 50 feet per mile. Slight folding or change in dip toward horizontality is sufficient to prevent further migration up-dip of the oil or gas. Small pools exist where variations in thickness occur. Since the Clinton sandstone varies considerably in thickness within short distances, a thick patch of the formation
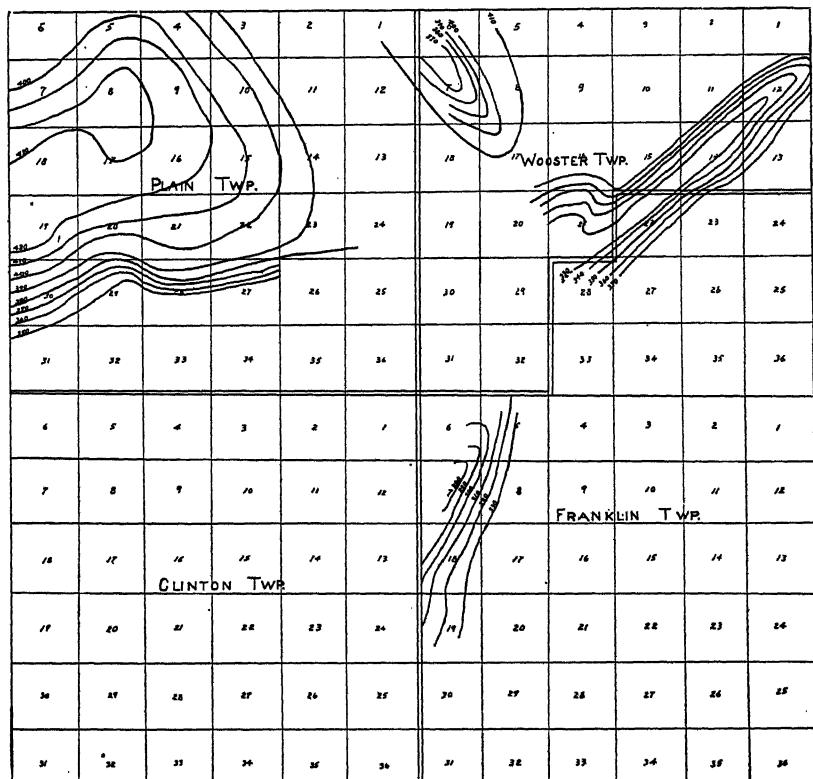
Fig. 4. Structure of the Berea sand. Structural contours indicate the depth of the top of the Berea sand from the well-head elevations.

can serve as a reservoir for oil and gas in the same manner as an anticline. As wells do not maintain their initial production very long in this area, strength was given at first to the theory that structure is not important. It is sufficient to say that best results are obtained where structure is given consideration.

The composition of the Clinton is also a deciding factor in determining where oil and gas can accumulate. A coarse-grained sandstone is better than a compact shale or limestone.

Not only does the Clinton vary in thickness in this area, but it changes in composition. A complete change is found to the west where it becomes shale, or to the south where it is calcareous. On the whole, the composition of the Clinton, as far as its oil-bearing possibilities are concerned, is at its best in the central portion of the state.

Wells in the Wooster area are considered very good producers if their initial production is above 10,000,000 cubic feet of gas per day. To obtain these results, a rock pressure of about 1,200 lbs. per square inch is required. A well is considered to be doing well if it operates at 500,000 cubic feet after 20 months, as the rock pressure has probably diminished to about 200 lbs.

GENERALIZED SECTION OF THE ROCKS PENETRATED IN DRILLING FOR OIL AND GAS
IN THE WOOSTER AREA.

SYSTEM	FORMATION		DRILLERS NAME	THICKNESS	CHARACTER
Quarternary	Glacial		Sand and Gravel	0–100	Boulder, clay, sand, pebbles, shale fragments and boulders.
Carboniferous	Logan and Cuyahoga		Shale and Sandstone	500–650	Dark shale with sandstone and shale interbedded.
	Sunbury				Black argillaceous bituminous shale.
	Berea s. s.		Berea Grit	30–60	Medium grained gray to buff sandstone.
Devonian or Carboniferous	Bedford sh.		Shale	20–50	Black and brown shale.
Devonian	Ohio Shale	Cleveland shale	Ohio shale	1,300–1,370	Thickens to the East. Black and brown carbonaceous shale, with numerous "iron stone" concretions. Some oil and gas.
		Chagrin form			
		Huron shale			
	Olentangy shale				
Unconformity	Delaware Limestone		Big Lime	1,030–1,080	Brown, gray, and blue limestones with few thin sandstone and shale beds in the lower half of the formation. A 40 foot salt bed lies 600 feet below top of Delaware limestone. Thickening takes place toward the East.
	Columbus Limestone				
	Monroe				
	Salina form				
	Niagara form				
Silurian	Clinton		Little Lime	150–170	Grey and red sandstone, dark shale with interbedded layers.
			Clinton Sand	5–45	Important oil and gas. Grey or red sandstone.
	Medina shales		Medina Red Rock	?	Red clay and shale. Little known as the drilling stops here.

FIVE MUCROTRICHAPHIS APHIDS[1]

GEORGE F. KNOWLTON AND MERLIN W. ALLEN[2]

This report deals with several species of aphids which are not typical *Macrosiphum*, yet are closely related to that genus. A new genus, *Mucrotrichaphis*, is erected and four of the five species considered are here described as new.

Mucrotrichaphis n. gen.

Mucrotrichaphis may be characterized as having: Weakly developed antennal tubercles which (most typically) scarcely exceed the vertex; slender, pointed hairs on vertex, antennae, body, and hind tibiae; cornicles well developed, cylindrical, imbricated and possessing reticulations; cauda elongate with several pairs of lateral hairs; general body shape as in *Macrosiphum;* antennae equal to or longer than the body; hind tibiae shorter than usual for typical *Macrosiphum;* ocular tubercles present.

Genotype—Mucrotrichaphis toti K.-A.

Taxonomy—Mucrotrichaphis species differ from typical *Macrosiphum* in having pointed rather than knobbed, flattened or blunt hairs on the vertex and antennae, possessing weakly developed antennal tubercles, and in being smaller than the average for *Macrosiphum* species. It differs from typical *Aphis* in having cornicles distinctly reticulated, cauda and antennae more elongate, with more typical *Macrosiphum* body shape. This genus would be more closely related to the Aphina than most genera in the Macrosiphina subtribe.

KEY TO APTERA

A. Unguis exceeding 4 times base of antennal IV.....................toti n. sp.
AA. Unguis not exceeding 4 times base antennal IV.

    B. Cornicles with 2 or 3 rows of reticulations; hairs on dorsum of abdomen not noticeably abundant...........................zerohypsi n. sp.
    BB. Cornicles with 4 to 5 rows of reticulations, hairs on dorsum of abdomen very numerous................................anomellus (K.-A.)

KEY TO ALATES

A. Unguis usually 1.75 times cornicles.
    B. Sensoria on antennal III exceeding 18 in number.........flavila n. sp.
    BB. Sensoria on antennal III not exceeding 18 in number........toti n. sp.
AA. Unguis seldom exceeding 1.5 times cornicles...............albicornus n. sp.

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[1]Contribution from the Department of Entomology, Utah Agricultural Experiment station.

[2]Research associate professor of entomology and research assistant, respectively.
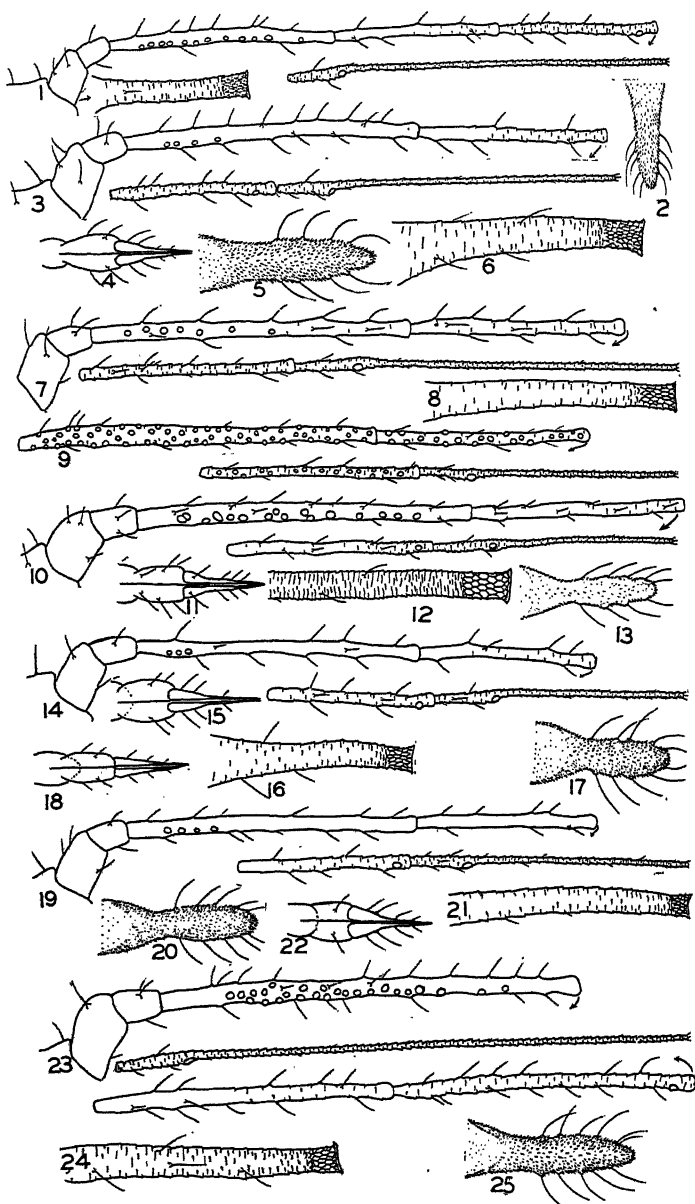
LEGEND FOR FIGURE

Mucrotrichaphis toti n. sp., alate 1–2, aptera 3–6, ovipara 7–8, alate male 9. *M. albicornus* n. sp., alate 10–13. *M. anomellus* (K.-A.), aptera 14–17. *M. zerohypsi* n. sp., aptera 18–21. *M. flavila* n. sp., alate 22–25.

Mucrotrichaphis toti n. sp.

Apterous vivipara—Body 1.43 to 1.59 mm. long; antennae 2.1 to 2.15, dark beyond basal one-half of III; antennal III, 0.51 to 0.59 with 2 to 4 sensoria on basal one-half; IV, 0.3 to 0.37; V, 0.3 to 0.34; VI, 0.11 to 0.12+0.51 to 0.62; rostral IV+V, 0.12 to 0.14 mm., reaching 3rd coxae; hind tibiae 0.96 to 1.08; hind tarsi 0.12 to 0.14; cornicles, 0.47 to 0.52, reticulation 0.08, 6 to 8 rows; cauda 0.24 to 0.34 mm. long.

Alate vivipara—Legs, cornicles, cauda and antennae dusky; body, 1.57 mm. long; antennae, 2.05, dark entire length; antennal III, 0.47 mm. with 11 to 12 sensoria in single row; IV, 0.32; V, 0.32; VI, 0.11+0.6; rostral IV+V, 0.12, reaching 3rd coxae; hind tibiae 0.92; hind tarsi 0.12; cornicles 0.3; cauda 0.2 mm. long.

Apterous ovipara—Body 1.33 to 1.54 mm. long; antennae, 2.34 mm., dusky beyond base of III; antennal III, 0.59 to 0.67 with 7 to 8 sensoria in a single row; IV, 0.4 to 0.44; V, 0.4 to 0.44; VI, 0.14+0.59; rostral IV+V, 0.14; hind tibiae 1.29 to 1.45; tibiae swollen and bearing sensoria on basal one-third; hind tarsi 0.13 to 0.14; cornicles 0.4 to 0.53, reticulated; cauda 0.24 to 0.3 mm. long.

Alate male—Body 1.64 mm. long; antennae 2.3; antennal III, 0.71 with approximately 60 sensoria; IV, 0.45 to 0.47 with 30 sensoria; V, 0.4 to 0.47 with 16 sensoria; VI, 0.13+0.5; hind tibiae, 1.25; hind tarsi, 0.14; cornicles 0.14 mm. long.

Collections—Type, 6 miles South of Woodruff, Utah, August 25, 1938 (G. F. Knowlton-D. E. Hardy); on *Artemisia tridentata;* paratypes, Monte Cristo, August 25, 1938 (Knowlton-Hardy); Logan Canyon (Cowley Canyon), August 12, 1934 (T. O. Thatcher) on *A. tridentata;* Logan Canyon (Wood Camp), September 2, 1934 (T. O. T.) on *A. tridentata;* Logan Canyon (Natural bridge trail), October 14, 1934 (T. O. T.) on *A. tridentata;* during 1939 collected in Utah at Allen's Canyon, several places in Logan Canyon, Huntsville, between Woodruff and Monte Cristo (Knowlton); on short sage at Cedar Breaks, Utah, August 9–10, 1939 (H. F. Thornley); and at Elko, Nevada, July 1, 1939 (Knowlton).

Taxonomy—This species differs from *zerohypsi* and *anomellus* in having longer unguis and more reticulation on cornicles.

Mucrotrichaphis albicornus n. sp.

Alate vivipara—Body 1.94 to 2.07 mm. long, color black; antennae 2.31 mm., dusky beyond basal one-half of III; antennal III, 0.61 to 0.67 with 12 to 16 sensoria; IV, 0.38 to 0.44; V, 0.36 to 0.42; VI, 0.12+ 0.65; rostral IV+V, 0.13 to 0.14, rostrum reaching 2nd coxae; hind tibiae 1.14 to 1.33; hind tarsi, 0.13 to 0.14; cornicles 0.45 to 0.51 with reticulated portions of lighter color than the remainder of cornicles; cauda 0.24 to 0.3 with 4 lateral hairs.

Collections—Type collected on *Artemisia*, Logan Canyon, August 23, 1936 (C. F. Smith); the paratype slide, Cedar Valley, May 10, 1936 (Knowlton-Smith). (This slide also contains an apterous *Prociphilus* sp.) Collected in Cache National Forest, Dry Bread Pond, July 8, 1939, on *Artemisia tridentata* (Knowlton), Smithfield, June 5, 1939 (R. L. Janes).

Taxonomy—This species differs from *M. flavila* and *M. toti* in having a shorter unguis.

Mucrotrichaphis anomellus (K.-A.)[3] n. comb.

Knowlton and Allen, Canad. Ent. 70: 75, 1938 (*Macrosiphum*).

Apterous vivipara—Body 1.43 to 1.96 mm. long; vertex aphis-like, with pointed hairs; antennae 1.96 to 2.15 mm. long, dusky to dark beyond basal half of III; antennal III, 0.51 to 0.67 mm. long, with 2 to 5 sensoria; IV, 0.3 to 0.36; V, 0.26 to 0.34; VI, 0.12 to 0.13+0.37 to 0.45; rostrum attaining 3 coxae; rostral IV+V, 0.14 to 0.16 mm. long; hind tibiae 1.02 to 1.14; hind tarsi 0.12 to 0.14; cornicles 0.43 to 0.49, dusky, with 3 to 5 hairs; cauda dusky, 0.3 to 0.34 mm. long.

Collections—Taken upon *Artemisia tridentata* at Little Cottonwood Canyon, Utah, April 24, 1937 (Knowlton); and Big Cottonwood Canyon, Utah, July 10, 1936 (Knowlton and C. F. Smith).

Taxonomy—This species differs from other species in the presence of numerous pointed hairs on the abdomen, in having fewer reticulations on cornicles than *M. toti* and more than *M. zerohypsi*.

Mucrotrichaphis zerohypsi n. sp.

Apterous vivipara—Body 1.64 to 1.76 mm. long; antennae 2.11 to 2.15 mm., black beyond base of antennal III; antennal III, 0.53 to 0.63 with 4 or 5 sensoria on basal one-half; IV, 0.36 to 0.41; V, 0.36 to 0.4; VI, 0.14+0.43 to 0.47; rostral IV+V, 0.14 to 0.15, reaching 3rd coxae; hind tibiae 1.12 to 1.23, distal one-half black; hind tarsi 0.12 to 0.14; cornicles 0.47 to 0.53, dark; cauda 0.32 to 0.33, dusky.

Collections—On *Artemisia*, one mile south of Dry Canyon (Cache County), Utah, April 8, 1934 (T. O. Thatcher).

Taxonomy—*Mucrotrichaphis zerohypsi* differs from *M. anomellus* in having less reticulation on cornicles and fewer hairs on the abdomen.

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[3]In the opinion of the writers and of several taxonomists of whom they inquired, *Macrosiphum anomellus* K.-A., 1938, is not preoccupied by *Macrosiphum anomalae* H.-F., 1931. Proposing a new name for this species would only inject another name into the literature which would need to be surpressed as a synonym.

Mucrotrichaphis flavila n. sp.

Alate vivipara—Body 2.11 to 2.34 mm. long, color dark; antennae, 3.07 mm. long, dusky beyond base of antennal III; antennal III, 0.77 to 0.82 with 20 to 26 sensoria scattered over entire length; IV, 0.54 to 0.57; V, 0.49 to 0.57; VI, 0.13 to 0.16+0.91 to 1.01; rostral, IV+V, 0.15 mm., reaching 2nd coxae; hind tibiae 1.51; hind tarsi 0.16; cornicles, 0.51, dark entire length; cauda 0.34 to 0.35, dark.

Collections—On *Artemisia*, Fishing Bridge, Yellowstone National Park, Wyoming, July 18, 1936 (G. F. Knowlton); Montpelier, Idaho, July 19, 1936 (Knowlton).

Taxonomy—*Mucrotrichapis flavila* differs from *M. albicornus* and *M. toti* in having longer antennae, more sensoria on antennal III and antennal tubercles more prominently developed.

A Thumb-nail Sketch of Animal Biology

A new textbook of animal biology which is in keeping with the present trend toward a panoramic view as an introduction to a field of study. Designed for a one-semester course accompanied by a laboratory, the authors urge the student in the words of Agassiz to "Study nature, not books." An introduction gives a panoramic view of the cell, cell-division, metabolism, nutrition, foods, digestion, respiration, excretion, reproduction and classification respectively in 23 pages. The major Phyla then are treated in the usual order with the discussion of the life processes in a selected "type-form." The vertebrate forms used are the perch and the frog. A discussion of Hormones and Vitamines; Mitosis, Spermatogenesis and Oogenesis; Heredity, Genetics and Evolution complete the textual part of the book, a total of 449 pages. An appendix includes a table of animal classifications which are annotated, and a glossary.

The book is well written in language which the beginner should be able to understand. The authors and publishers are to be complimented upon the format and illustrations; mechanically it is an admirable job.

If this text be used in the manner suggested by the author's preface it will doubtless be a contribution rather than an addition to the long list of available zoology textbooks.—*P. E. Sheaffer.*

An Introduction to Biology, by John B. Parker and John J. Clarke. 503 pp. St. Louis, The C. V. Mosby Company. 1939. $3.75.

The Elements: Stories of Their Discovery

"The material blessings that man enjoys today have resulted largely from his ever-increasing knowledge of about ninety simple substances, the chemical elements, most of which were entirely unknown to ancient civilizations . . . . it is hoped that these chapters may not only render tribute to the honored men and women who helped to reveal the hidden chemical elements, but that they may also serve to acquaint chemists and others with these great achievements . . . . an attempt has been made to relate all important steps in the discovery (of the elements) as fairly and completely as possible . . . . ." These exerpts from the Foreword describe the book. This fourth edition is enlarged and revised. The material is interestingly written, well documented and pleasingly enriched with a wealth of pictorial material. The simple, novel style of presentation makes the book interesting to a teacher as well as a student. The treatment of each topic seems to be complete without quibbling; this serves to contribute to the authenticity of the subject material and to increase one's confidence in the validity of the conclusions of the author. This book well deserves a foremost place in historical chemical literature.—*A. B. Garrett.*

Discovery of the Elements (Fourth Edition) by Mary Elvira Weeks. v+470 pp. Easton, Pa., Mack Printing Company, for the Journal of Chemical Education. 1939. $3.50.

A NEW ACMAEODERA FROM THE SOUTHWEST
(COLEOPTERA: BUPRESTIDAE)

JOSEF N. KNULL

The Ohio State University, Columbus, Ohio

Acmaeodera paradisjuncta n. sp.

Male—Resembling *A. disjuncta* Fall in form and markings. Elytra black with irregular yellow and red markings. Head, pronotum and ventral surface black with cupreous reflection. A yellow lateral stripe on each side of pronotum not extending to the borders.

Head concave, densely coarsely punctured, pubescence moderately long; eyes large, finely granulate; antennae not reaching to middle of pronotum, serrate from the fifth joint.

Pronotum much wider than long, widest near base; side margins visible throughout from above, broadly rounded from near base toward anterior end, acutely rounded at base; disk convex, a slight median depression, another deep depression on each side at base; surface coarsely punctured, punctures separated by more than their own diameters in middle, more numerous in front, at base and along sides, pubescence moderate.

Elytra slightly wider than widest part of pronotum, widest near base; sides constricted at base and middle, flared nearly horizontally back of middle; margins serrate from middle to apices; disk convex, umbone prominent, eighth interspace prominently raised back of middle, ninth flattened; surface with punctures of striae moderate in size, separated by about their own diameters, much larger along sides, punctures of interspaces small, pubescence moderate.

Front margin of prosternum retracted, sides not reaching the front angles, prosternum trisinuate in front. Abdomen coarsely punctured; last ventral with a thick subapical plate. Pubescence of ventral surface moderately long.

Length, 10.8 mm.; width, 4.2 mm.

Female—Slightly more robust than the male.

Holotype male labeled Davis Mts., Texas, June 8; allotype from Reeves County, Texas, June 12 (D. J. & J. N. Knull, Collectors). Other records include: Texas—Chisos Mts., June 9, Davis Mts., Sept. 8, Terrell County, June 6 (D. J. & J. N. Knull); Chisos Mts., July 19 (H. A. Wenzel). Mexico—Three specimens without definite localities.

Type, allotype and paratypes in writer's collection; paratypes in collection of The Ohio State University and of C. A. Frost, who kindly compared material with the LeConte types.

This species closely resembles *Acmaeodera disjuncta* Fall and undoubtedly is confused with it in collections. It can be separated by its less robust structure and by the flare of the sides of the elytra. The male genitalia of the two species are also distinct. It falls in the Sinuata Group according to Fall[1] and should come next to *disjuncta* Fall.

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[1]H. C. Fall. Jour. N. Y. Ent. Soc., Vol. 7, p. 5, 1899.

FACTORS WHICH AFFECT THE GROWTH OF A COLORLESS FLAGELLATE, ASTASIA KLEBSII, IN PURE CULTURES*

HERMAN VON DACH

Mary S. Muellhaupt Scholar in Zoology,
The Ohio State University

INTRODUCTION

This paper is the first of a series of studies on various factors affecting the growth and decline of populations of a protozoan, *Astasia klebsii*, in pure clone culture. In the past, a number of similar investigations have been made on pure cultures of bacteria and yeasts, but very few on the protozoa. The great importance of working with *pure* (i. e., bacteria-free) cultures under controlled conditions is now generally recognized (see Phelps, 1935), and need not be elaborated upon here. In the present paper growth is considered in relation to hydrogen ion concentration, type and concentration of food material, and oxygen tension.

This work has been done under the supervision of Professor W. J. Kostir, of The Ohio State University, who suggested the general problem and supplied the clone culture of *Astasia klebsii*. I am grateful to him for suggestions and criticisms.

THE ORGANISM

The species used in these experiments was *Astasia klebsii*, first described by Lemmermann in 1910, and further studied and described by Pringsheim (1936). The shape of this colorless flagellate is at times altered by protoplasmic contractions, known as euglenoid movements or metaboly. Nutrition is saprozoic. Food reserves of paramylum, a starch-like polysaccharide which does not respond to the usual iodine test for starch, are stored as small granules in the cell. No thick-walled resting stage is known. The cells of the strain used in this investigation measure 40 to 50 microns in length by 10 to 15 microns in width; these dimensions conform more closely to Pringsheim's description than to Lemmermann's.

The delicate striation of the pellicle, mentioned both by Lemmermann and by Pringsheim, is not easily seen, but is definitely demonstrable with the best optical equipment.

This species has not previously been studied in bacteria-free culture.

MATERIALS AND METHODS

Cells from a stock clone culture of *Astasia klebsii* were washed bacteria-free, employing the "migration-pipette" method of Glaser and Coria (1930), and pure cultures were established.

The following inorganic solution was used as the basis of all culture media:

KNO_3.............................. 0.5 g.
KH_2PO_4........................... 1.5 g.
$MgSO_4.7H_2O$...................... 0.1 g.
NaCl............................... 0.1 g.
$CaCl_2$............................. 0.01 g.
$FeCl_3$............................. trace
Triple-distilled water.................. 1 liter
    (Distilled in Pyrex still)

The following culture media were used:

Medium B-1: 1.0 g. Bacto-Tryptone per liter of inorganic solution.
Medium B-5: 5.0 g. Bacto-Tryptone per liter of inorganic solution.
Medium B-25: 25.0 g. Bacto-Tryptone per liter of inorganic solution.
Medium C: 2.0 g. anhydrous sodium acetate per liter of Medium B-5.

The pH of each medium was adjusted to the desired level by addition of N/1 HCl or N/1 NaOH, colorimetric determinations being made with a Hellige comparator. 9.3 cc. portions of medium were measured into 20 x 150 mm. Pyrex culture tubes which were then plugged with cotton and autoclaved.

A single flask culture was used as the source of the inoculum in an experiment. Equal volumes of inoculum were transferred to dilution flasks of the various types of media employed; from each dilution flask in turn 1.0 cc. portions were transferred to the culture tubes of the corresponding series. In this way the original inoculum was greatly diluted (from 50 to 1000 volumes in different experiments).

The initial number of cells per cc. was determined. After varying periods of incubation (at 25° C. ± 1° unless otherwise noted) the final number of cells per cc. was determined. Cell counts were made by the Sedgwick-Rafter counting method as described by Hall, Johnson, and Loefer (1935). In each instance the mean count of several samples from three cultures was computed. Increase in number of cells was the only criterion of growth studied.

The customary bacteriological techniques and tests for purity of the cultures were employed. Contaminated cultures were discarded.

TABLE I

EFFECT OF PH ON GROWTH IN 0.5% TRYPTONE
Medium B-5 used in all series.
Inoculations from a Medium B-5 culture at pH 5.8.
Initial cell concentration = 420 cells per cc.

Culture Series	No. Cells per cc. at 4 Days	No. Cells per cc. at 8 Days	Final pH
Series A—Initial pH 3.2	1,400	10,360	3.2
Series B—Initial pH 4.2	4,220	29,330	4.2
Series C—Initial pH 5.1	12,110	29,980	5.2
Series D—Initial pH 6.0	13,940	31,830	6.0
Series E—Initial pH 7.0	3,830	13,310	7.0
Series F—Initial pH 7.9	1,890	3,770	7.8
Series G—Initial pH 8.4	1,720	2,540	8.2

EFFECT OF HYDROGEN ION CONCENTRATION

Hydrogen ion concentration has long been recognized as an important ecological factor affecting the growth of protozoa. Various workers have determined the pH relationships of a number of protozoa in pure culture, including several species of *Euglena;* these results were summarized by Loefer (1935). The first two experiments of the present study dealt with the effects of this factor in two different types of medium: 0.5% tryptone (Medium B-5), and acetate-tryptone (Medium C).

In 0.5% tryptone at eight days there was optimum growth at pH 6.0, a range of nearly equal growth between pH 4.2 and 6.0, less growth at pH 3.2 and 7.0, and very little growth at

pH 7.9 and 8.4. (See Table I.) The limits of the pH range of growth were not revealed by this experiment. Comparison of these results with those given for other euglenoids in Loefer's (1935) table of pH relationships shows that *Astasia klebsii* has a wider pH range of growth and a lower optimum pH than most previously-studied members of the group.

In acetate-tryptone, maximum growth was at pH 5.1 and 5.9, with good growth occurring over the range pH 4.4 to 6.7, much less growth at pH 7.4 and 8.2, and no growth at all at pH 3.8. (See Table II.)

TABLE II

EFFECT OF pH ON GROWTH IN ACETATE-TRYPTONE

Medium C used in all series.
Inoculations from a Medium C culture at pH 5.9.
Initial cell concentration = 100 cells per cc.
Incubation at 26.5° C. (=0.5°).

CULTURE SERIES	AT 4 DAYS		AT 8 DAYS	
	No. Cells per cc.	pH	No. Cells per cc.	pH
Series A—Initial pH 3.8	60	3.8	50	3.8
Series B—Initial pH 4.4	1,460	4.4	310,600	4.7
Series C—Initial pH 5.1	6,600	5.1	764,000	7.6
Series D—Initial pH 5.9	6,920	5.9	748,000	8.2
Series E—Initial pH 6.7	4,320	6.7	228,200	7.5
Series F—Initial pH 7.4	1,580	7.4	11,600	7.4
Series G—Initial pH 8.2	550	8.2	960	8.1

Comparison of Table I and Table II shows that addition of acetate to 0.5% tryptone medium greatly increases growth over the range pH 4.4 to 6.7, has little effect above pH 7.0, and completely inhibits growth at pH 3.8.

In the foregoing experiments, the tryptone cultures and the acetate-tryptone cultures had been inoculated from different source cultures and had been run at slightly different temperatures. As a further check on these general results, another experiment was performed to compare growth at pH 5.9 in 0.5% tryptone and in acetate-tryptone, making inoculations

from a single source culture. The results, presented in Table III, clearly show the great increase in growth produced at this pH by addition of acetate to the tryptone medium.

In Table III the marked increase in pH in the acetate-tryptone cultures is in contrast to the constancy of pH observed in the tryptone cultures. The same phenomenon was observed in the other experiments included in this paper. In general, the pH of tryptone cultures remained practically constant; on the other hand, in vigorously-growing cultures in acetate-tryptone medium there was a marked increase in pH. The following tentative explanation is suggested: Probably the sodium

TABLE III

GROWTH IN TRYPTONE AND IN ACETATE-TRYPTONE AT pH 5.9

Inoculations from a Medium C culture of pH 5.9.
Initial cell concentration of cultures = 1700 cells per cc.

CULTURE SERIES	AT 3 DAYS		AT 8 DAYS	
	No. Cells per cc.	pH	No. Cells per cc.	pH
Series A Medium C Initial pH 5.9	141,990	6.7	702,520	8.3
Series B Medium B-5 Initial pH 5.9	53,390	5.9	57,840	5.9

acetate partly hydrolyzes to form sodium hydroxide and acetic acid, the acetic acid being oxidized by the cells to CO_2 and water; the accumulation of sodium bicarbonate and sodium hydroxide results in a gradual alkalinization.

According to the review by Hall (1939), it has been shown that acetate increases growth in a number of saprozoic flagellates, including three other species of *Astasia*. The toxic effect of acetate on protozoan cultures at low pH was discussed by Jahn (1934). He suggested that at low pH much of the acetate would be in the form of undissociated acetic acid, and that only the undissociated acetic acid molecule was toxic.

EFFECT OF OXYGEN TENSION

It has been shown that cultures in acetate-tryptone at pH 5 or 6 develop dense concentrations of cells (700,000 cells per

cc.); this suggested that this species may be anaerobic or nearly so. As Rahn (1932, p. 80), speaking of bacteria cultures, says: "There can be no doubt that in a test-tube culture or flask culture of aerobes, all cells will exist under practically anaerobic conditions except those in the very top surface layer." Likewise, Pringsheim (1936) had grown bacteria-containing cultures of *Astasia klebsii* under films of paraffin oil, which points to the same possibility. To test this point, the experiment summarized in Table IV was performed, employing acetate-tryptone of initial pH 5.9 as the culture medium.

TABLE IV

EFFECTS OF OXYGEN TENSION ON GROWTH IN ACETATE-TRYPTONE
Medium C (initial pH 5.9) used in all series.
Inoculations from a Medium C culture of pH 5.9.
Initial cell concentration of cultures = 1700 cells per cc.

CULTURE SERIES	AT 3 DAYS		AT 8 DAYS	
	No. Cells per cc.	pH	No. Cells per cc.	pH
Series A—Control	141,990	6.7	702,520	8.3
Series B—Nearly Anaerobic	41,040	6.2	549,400	7.6
Series C—Constant Aeration	41,140	6.2	638,960	8.4

In this experiment the cultures of one series (B) were treated as follows: Each newly-inoculated culture tube was fitted with a rubber stopper equipped with a glass inlet tube extending almost to the bottom of the culture tube and an outlet tube which came only to the bottom of the rubber stopper. Tank nitrogen was shaken in a pressure bottle containing strong pyrogallate solution to absorb almost all the oxygen present. The treated gas was sterilized by passing through cotton, saturated with water vapor and then bubbled vigorously through the cultures for 12 minutes, after which the gum rubber connections on inlet and outlet tubes were clamped off. Culture tubes so treated presumably contained only minute amounts of oxygen; but they could not be regarded as completely oxygen-free, for pyrogallate solution does not absorb every trace of oxygen, and also oxygen can diffuse through rubber tubing.

In another series (C) the culture tubes were fitted with rubber stoppers and glass tubing as in Series B, and a constant stream of sterilized water-saturated air was bubbled through the cultures during the entire period of incubation.

The oxygen tension in the cotton-plugged controls (Series A) was presumed to be more or less intermediate between that in Series B and that in Series C.

It will be seen from Table IV that both the constantly-aerated cultures (Series C) and the nearly anaerobic cultures (Series B) showed lower growth rates, but also showed longer periods of comparatively vigorous growth, than the controls of Series A. As a result, at eight days the population levels in the former two series were not greatly less than that of the controls. Jahn (1936), working with the ciliate *Glaucoma pyriformis* and the flagellate *Chilomonas paramecium*, studied growth in aerated cultures and in non-aerated cultures; his results agree on the whole with those of the corresponding part of the present experiment.

EFFECT OF DIFFERENT CONCENTRATIONS OF TRYPTONE UPON THE GROWTH CURVE

Among the bacteria and yeasts considerable work has been done on the determination of the various phases of the growth curves, and on the factors affecting these phases. In much pure-culture work on the protozoa, however, the general practice has been to determine relative amounts of growth after only one or two arbitrarily-chosen periods of incubation. Sometimes it is assumed that logarithmic growth-rates are being determined, but usually no attempt is made to differentiate between the various phases of the growth curve. As a result, such work on the protozoa has lacked completeness and precision. The results summarized in Tables I and II of the present paper illustrate the shortcomings of this procedure. A fuller and more satisfactory picture of the growth of a culture is afforded by growth curves—especially logarithmic curves, in which the various phases of growth can readily be seen at a glance.

The only published detailed study of the growth curve of a protozoan in pure culture is that on the ciliate *Glaucoma pyriformis* by Phelps (1935, 1936). He compared his findings on this form with the data on the growth curves of yeasts and bacteria as summarized by Buchanan and Fulmer (1928) and by Rahn (1932).

The obvious desirability of ascertaining the rate of growth at various stages in the development of astasia cultures, and thus constructing true growth curves, led to the following procedure. An experiment was undertaken to determine the course of growth in tryptone media of 0.1%, 0.5%, and 2.5% concentrations. Inoculations were made from a 7-day-old culture in 0.5% tryptone which was probably in the logarithmic growth phase. Initial cell concentrations of the cultures were 400 cells per cc. The hydrogen ion concentration of all cultures remained constant at pH 5.8. The results of this experiment are presented in Figure 1.

Buchanan and Fulmer (1928) divide the growth curve of bacteria into the following phases: (1) the initial stationary phase, during which no cell division occurs; (2) the lag phase, during which the division rate increases with time; (3) the logarithmic growth phase, during which the rate of cell division is constant and at a maximum; (4) the phase of negative growth acceleration, during which the division rate decreases with time; (5) the maximum stationary phase, during which the population is constant and at a maximal level; (6) phase of accelerated death, during which the rate of decrease in the number of living cells increases with time; (7) so-called logarithmic death phase, during which the rate of decrease of living cells is constant. In this paper only the first five phases of growth will be discussed.

In the present experiment, though counts were made at rather wide intervals, the general trends of the growth curves are fairly clear. (See Fig. 1.)

No initial stationary phase is evident from the data at hand.

The growth curve of the 0.5% tryptone cultures showed a very brief and ill-defined lag phase which went quickly into the logarithmic growth phase. The 0.1% tryptone cultures showed a longer and more well-defined lag phase, which was still more pronounced in the 2.5% tryptone cultures.

Concerning a similar situation, Phelps (1936) states: "Animals [*Glaucoma*] taken from the stock cultures containing 0.1% yeast extract, upon being placed in much higher concentrations suffered a shock, and failed to divide for sometimes as much as 30 hours." In the present experiment it may be postulated that astasias from the 0.5% tryptone inoculum suffered some shock on transfer to medium of a different tryp-

tone concentration, whether higher or lower, and this shock resulted in a well-defined lag phase of growth.
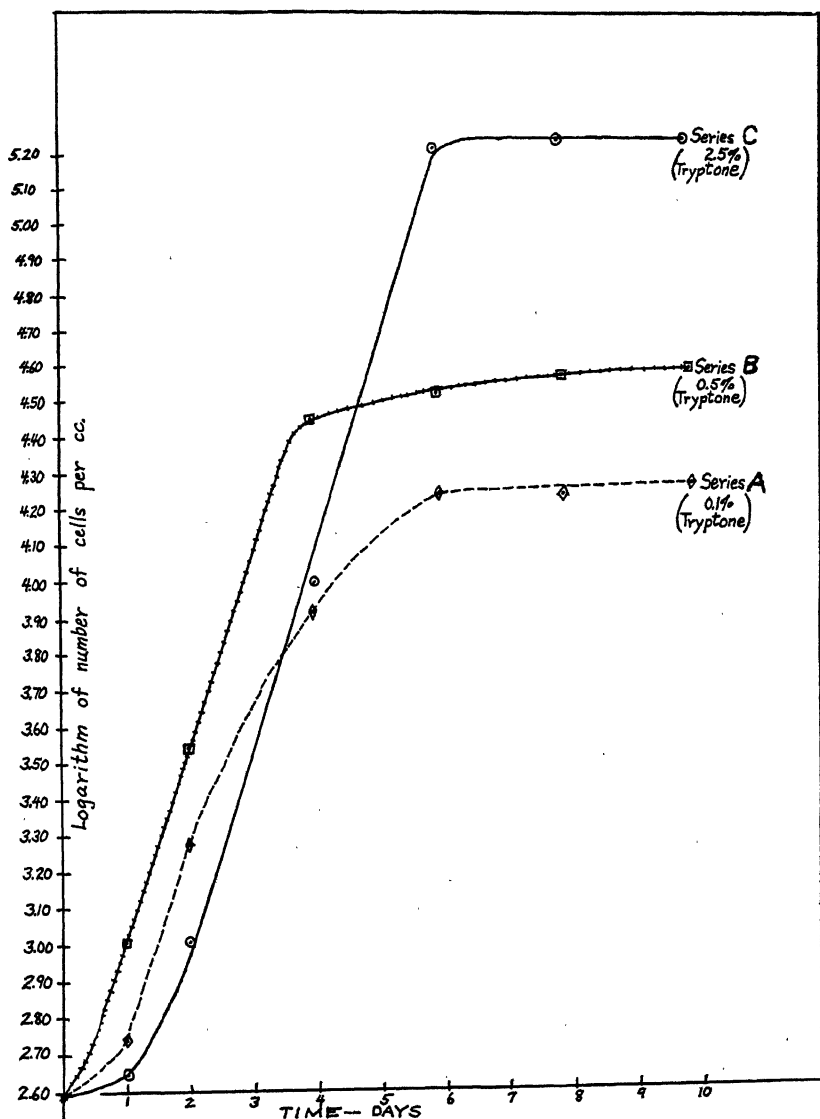
Fig. 1. Growth of *Astasia klebsii* in different concentrations of tryptone.

Logarithmic growth phase. When the logarithm of the number of cells per cc. is plotted against time, this part of the growth curve will be an ascending straight line. (See Fig. 1.)

The time required for the number of cells in a culture to double (presumably by each cell dividing into two cells) is called generation time (g). During the logarithmic growth phase g is a constant. According to Rahn (1932) the standard formula for generation time is

$$g = \frac{t \, \log 2}{\log b - \log a}$$

where a = initial number of cells, and b = number of cells after time t. Applying this formula to the logarithmic growth periods of the cultures in this experiment, the values given in Table V were obtained.

TABLE V

GROWTH RATES IN LOGARITHMIC PHASE IN DIFFERENT
CONCENTRATIONS OF TRYPTONE

Culture Series	Portion of Logarithmic Growth Period Taken in Calculation of g	g Generation Time of Logarithmic Phase
Series A—0.1% tryptone	1 day to 2 days	13.6 hours
Series B—0.5% tryptone	1 day to 2 days	13.4 hours
Series C—2.5% tryptone	2 days to 6 days	13.1 hours

Table V shows that in the logarithmic growth phase the generation time is practically constant in tryptone concentrations between 0.1% and 2.5%. However, the duration of the logarithmic growth phase increased with increasing food concentration, as Figure 1 shows.

At the end of the logarithmic growth phase, the growth curves of Series B and C showed abrupt decline in division rate as the phase of negative growth acceleration began; while the curve of Series A showed a prolonged gradual decline in growth rate.

Maximum stationary phase. In each series of cultures, the cell concentration at 20 days and at 22 days was very slightly less than that at 10 days. Consequently the cell concentration at 10 days may be regarded as the maximum yield in each case.

According to Rahn, when the maximum populations are proportional to the concentrations of food in the medium, then food is the sole limiting factor of the growth of the populations,

and accumulation of metabolic wastes plays no part in such limitation.

In Table VI, Series B and C show such a proportionality between yields of cells and concentrations of medium, indicating that possibly food supply is here the limiting factor. Yet this relationship between food and cell yields breaks down when the weaker concentrations of food are compared (Series A and Series B).

No explanation is available for this discrepancy. Phelps (1936) found the same general sort of situation in *Glaucoma*: namely, that there was a proportionality between yields of animals and concentrations of medium, which however did not hold true for very weak food concentrations.

TABLE VI

Food Concentrations and Maximum Populations

Culture Series	Food Concentration Ratio (tryptone)	Maximum Populations (No. Cells per cc.)	Ratio of Maximum Populations
Series A	0.1%	18,330	0.48
Series B	0.5%	38,100	1.0
Series C	2.5%	173,100	4.54

Besides the points already mentioned, the following conclusions from the present experiment are in substantial agreement with Phelps' results on *Glaucoma*: (1) The generation time during the logarithmic growth phase is approximately the same at several concentrations of food; (2) there is an increase in duration of the logarithmic growth phase with increasing food concentration.

SUMMARY

Bacteria-free clone cultures of *Astasia klebsii* in 0.5% tryptone medium after 8 days at 25° C. showed optimum growth at pH 6.0, a range of nearly equal growth between pH 4.2 and pH 6.0, less growth at pH 3.2 and pH 7.0, and very little growth above pH 7.0.

Addition of acetate to the tryptone medium greatly increased growth over the range pH 4.4 to 6.7, had little effect above pH 7.0, and completely inhibited growth at pH 3.8.

In tryptone cultures pH remained practically constant, while in vigorously-growing acetate-tryptone cultures there was a marked increase in pH.

In acetate-tryptone at initial pH 5.9, both nearly-anaerobic cultures and constantly-aerated cultures showed slower growth than the controls, but the yields of all three series of cultures after eight days were fairly comparable.

Growth curves were determined at 25° C. for three different concentrations of tryptone (0.1%, 0.5%, 2.5%). During the logarithmic growth phase the generation time was slightly greater than 13 hours at all three food concentrations; duration of this phase increased with increasing concentration of tryptone. In the case of the 0.5% and 2.5% tryptone cultures the maximum populations were roughly proportional to food concentration, but this proportionality did not hold for the 0.1% tryptone cultures.

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THREE NEW SPECIES OF PSYLLIDAE WITH NOTES ON OTHERS

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Livia aba n. sp.

Length to tip of forewing 3.2 mm.; forewing 2.2 mm.

Color: Head and thorax brownish red above; venter black. Abdomen brown above with white venter. Forewings yellowish.

Vertex angulate in front as in *coloradensis* Crawford. Eyes rather prominent for the genus. Forewings with membrane rugose but hyaline.

Dorsal valve of female greatly arched in caudal half with extreme apical portion suddenly narrowed to a short blunt apex. Ventral valve narrowly triangular in lateral aspect.

Female holotype from Yellowstone Park, Wyoming, collected by Herbert Osborn, is in his collection at Ohio State University.

Livia vernaliforma n. sp.

Length to tip of forewing 3 mm.; forewing 2.2 mm.

Color: Golden yellow washed with orange. Venter of head and thorax black. Forewings very light yellow.

Vertex short but emarginate in front similar to *vernalis* Fitch. Forewing over twice as long as broad; membrane hyaline, rugose.

Dorsal valve of female similar to *vernalis* except much more sinuate with a much narrower apex; ventral valve not as heavy.

Female holotype, Williston, N. D., collected by Herbert Osborn, is in his collection at Ohio State University.

Trioza sembla n. sp.

Length to tip of forewing 2.7 mm.; forewing 2.2 mm.

Color: Light orange except for black eyes, black antennae beyond second segment, brown tarsi, and yellow margin around vertex.

Head as broad as thorax, both finely pubescent. Genal cones two thirds as long as vertex, acute, slightly divergent. Antennae a little longer than width of head. Forewings little over twice as long as broad; apices subacute.

Proctiger of male with large caudal lobes. Forceps shorter than proctiger. In lateral aspect: Caudal margin practically straight, cephalic margin slightly produced cephalad, apices slightly rounded rather than truncate. In caudal aspect: thick basally, slightly bowed, narrowed evenly to apices.

Male holotype, Painted Desert, Ariz., VI-25, D. J. and J. N. Knull collectors, is in the Ohio State University collection.

Aphalaroida masonici n. n.

This species was described as a species of Euphyllura with some doubt as to placement. Since the frons is visible, although very

indistinct, the species belongs in *Aphalaroida*. The name *acacia* is preoccupied by Crawford's species so the name *masonici* is proposed. (Ann. Ent. Soc. Amer. 31: 442, 1938.)

Psylla tuthilli n. n.

Mr. Tuthill has called the writer's attention to the fact that the name *virida* is preoccupied by *viridis* Hartig. The writer takes pleasure in naming this species after Mr. L. D. Tuthill of Iowa State College. (Can. Ent. 71: 212, 1939.)

Phylloplecta minuta Crawford

Mr. Oman has called attention to the fact that the writer errored in proposing the name *multidubiata* for Mallys' *salicis*. The name should be *minuta* Crawford. It also follows that the variety *P. multidubiata breviradia* should be changed to *P. minuta breviradia*. (Can. Ent. 71: 211, 1939.)

Quantitative Zoology

Until recent years zoology has generally been considered a non-mathematical science. As a consequence, many professional zoologists have had only an elementary training in mathematics, and no training whatsoever in the use of statistics. The development of statistical techniques and their applications to the interpretation to various types of data have become so widespread in the last few years that zoologists can ill afford to be without at least an elementary understanding of statistical principles. While numerous statistics texts have recently appeared, many are of a too technical and advanced nature for the beginner.

The new book "Quantitative Zoology," by Simpson and Roe is designed to meet the needs of the zoologist who has had no training in statistics. The book is primarily a text on methodology in zoology, and includes, in addition to the portions on general statistics, chapters on Types and Properties of Numerical Data, Mensuration, Graphic Methods and Growth. The authors are paleontologists and present their material from the standpoint of the zoologist and paleontologist. Twelve chapters deal with elementary statistics as applied to zoological data, including treatments of correlation, regression and tests of association. They have not followed Fisher in using a double set of symbols and terms, one for the parameters of populations and one for the calculated estimates of these parameters. The text presupposes no knowledge whatever of statistics, and of mathematics no more than elementary algebra. The appendix contains sections on calculations, symbols, formulae and a glossary. Quantitative Zoology appears to be admirably adapted to the zoologist and paleontologist, as a practical guide in the interpretation of many types of data.—*D. C. Rife.*

Quantitative Zoology, by George Gaylord Simpson and Anne Roe. xvi+414 pp. New York, McGraw-Hill Book Company, Inc. 1939. $4.00.

BOOK NOTICES

Principles of Genetics

Rapid advances in our knowledge of chromosomal aberrations, polyploidy, giant chromosomes, sex determination, developmental genetics, the effects of various types of selection, and simple applications of tests for goodness of fit have been made in recent years. In their third edition of "Principles of Genetics," Sinnott and Dunn have included up to date discussions of all the above phases of modern genetics. The material is presented with unusual clarity. The order of topics is much the same as in the earlier editions. Excellent problems are given at the end of each chapter. Illustrations and diagrams are numerous.

We have only two adverse criticisms, both of a minor nature. Too much material is given in some of the chapters for the average beginning student to grasp easily. For example, Chapter V, entitled the Expression and Interaction of Factors, includes not only modifications of two factor crosses, but also multiple alleles, modifying factors, multiple effects of a single factor and lethal factors. In many of the problems assumptions are made which are not justified. For example, blue eyes and left-handedness are assumed to be simple recessives. Numerous instances of clear cut simple factor traits, such as albinism and polydactylism are known, and would seem more appropriate as problem material.

The book is an unusually good text for superior beginning students, especially those intending to major in some phase of biology.—D. C. Rife.

Principles of Genetics (3rd edition), by Edmund W. Sinnott and L. C. Dunn. xvi+408 pp. New York, McGraw-Hill Book Co., Inc. 1939.

Adult Intelligence

There has finally been composed a good clinical test of adult intelligence; a test based on the development of psychological functions throughout the span of adult years, rather than on the years during which the growth of intellectual capacities is most marked. The direct outcome of this effort is that we may now determine the relative brightness of adults without having to resort to scores whose relationship with the factor of age is undetermined, and therefore of questionable significance.

"The Measurement of Adult Intelligence" is the published account of the logic and method employed by Dr. David Wechsler in constructing the "Bellevue Intelligence Examination." The examination is arranged as a point scale to be administered individually, and is composed of ten tests; five verbal tests and five tests of performance. Scores may be obtained for the verbal or performance aspects as well as for the full scale—depending on the clinical purpose.

The book is divided into three main parts; the nature and classification of intelligence, the description of the tests and their standardization as a scale, and the directions for administering the tests plus statistical appendices and I. Q. tables. Without detracting one bit from Dr. Wechsler's accomplishment, it should be said that pracically all of the principal concepts employed by him have been described before. His main contribution lies in his combination of these features into a practical and sound measure of adult intelligence.

The chief characteristic of the book, as of the examination it describes, is the application of normal frequency statistics to groups arranged on the basis of age and score. Since the function of the I. Q. is to provide an index of relative brightness, the author devises just such an index by measuring intelligence at each age and obtaining standard scores for each year level. The comparable units resulting from this procedure yields an index which has the same function at any age, and therefore "maintains the same meaning throughout the life of the individual." A

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similar application of the Probable Error to the problem of classification yields levels such as "normal," "superior" and "defective" which are of uniform significance for any intelligence test at any age.

One of the most interesting of the theoretical sections of the book deals with the problem of mental deterioration. Employing a "rate of change" concept, Dr. Wechsler lays the foundation for a precise method of measuring psychological effects of deterioration. The essence of the scheme involves measurement of the rate of decline characteristic of various test abilities. Since certain abilities are affected only slightly by age (after 25) while others are markedly affected, the relative difference between the two should be the greater the longer the period of deterioration, or the more severe its effects. The author points out, however, that the problem is not as simple as it may appear on the surface. The complications yet to be eliminated concern determination of the limits of normal deterioration, interpretation of the large variations in the deterioration of different individuals (making application to single cases difficult) and determination of differences in deterioration occasioned by the various neuropathic disorders.

In presenting the results of standardization Dr. Wechsler gives adequate proof that the Bellevue scale is reliable as well as valid, since it correlates highly with itself and with the Stanford-Binet. In this connection one point is of special interest. A bi-serial correlation between Stanford-Binet I. Q.'s and psychiatric recommendations gave a coefficient of .33$\pm$.071. The same procedure using the Bellevue examination yielded a bi-serial coefficient of .79$\pm$.048. It is obvious, therefore, that the measure of intelligence given by the Bellevue examination, although having much in common with that given by the Stanford-Binet, has a decided clinical emphasis.

The book is a clear account of that which the author has thought and done, and leaves few questions to be asked.—*Milton M. Parker.*

The Measurement of Adult Intelligence, by David Wechsler. ix+229 pp. Baltimore, the Williams and Wilkins Co. 1939. $3.50.

Laboratory Guide in Entomology

Anyone teaching an introductory course in entomology will want to examine the new laboratory guide prepared by Prof. Robert Matheson for the introductory course in entomology at Cornell University. This guide covers a diversified field of subject matter and presents the same in an excellent manner. Some of the topics covered are external and internal anatomy including types of mouth-parts; characteristic structures of the adults of the most important orders, and keys to families; adaptations among insects; social life; insects as pollinators; relationship to disease of man and animals; the problem of control, etc. At the end of the book there occurs a short chapter on how to collect, prepare, mount, preserve and rear insects and a short glossary of scientific terms. Many excellent drawings are found throughout the guide which students are asked to label.—*A. Peterson.*

A Laboratory Guide in Entomology by Robert Matheson, 135 pp. Ithaca, The Comstock Publishing Co., Inc. 1939. $2.00.

CRINOIDS FROM THE SILICA SHALE, DEVONIAN, OF OHIO

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Recently the writer has had the privilege of examining some crinoids from the private collection of V. E. Ladd of Toledo, Ohio. The specimens were all collected from the Silica shale in the Kelley's Island Lime and Cement Company quarry at Silica, Lucas County, Ohio. They represent two new species, and a young specimen of *Arthracantha carpenteri* (Hinde) which has the arms exceptionally well preserved.

One of the new species, *Gilbertsocrinus ohioensis* n. sp., belongs in a genus heretofore unrecognized in the Devonian strata of Ohio. Thus far eight species of this interesting genus have been collected in rocks of Hamilton age. The species and their occurrences are as follows: *G. greenei* Miller and Gurley and *G. indianensis* Miller and Gurley from Clark County, Indiana; *G. spinigerus* (Hall) from the Moscow (Ludlowville) of western New York; *G. alpenensis* Ehlers from the Hamilton near Alpena, Michigan, and the Ludlowville of western New York; *G. intersculptus* Goldring from the Skaneateles formation, Unadilla valley, New York; *G. rarispinus* Goldring from the Moscow formation, Georgetown, New York; *G. spinonodosus* Goldring, Tichenor formation (Ludlowville), Eighteen Mile Creek, New York; and *G. multicalcaratus* Goldring from the Kashong beds of the Moscow formation, East Bethany, New York. Goldring has shown that *G. indianensis* is synonymous with *G. spinigerus*.

This very interesting series of species, although closely related, show distinct and progressive changes in ornamentation and in the development and distribution of spines. The Ohio species is characterized particularly by the development of strong nodes on only the radial plates.

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The second new form, *Euryocrinus? laddii* n. sp., has been placed only tentatively in the genus *Euryocrinus*. It doubtless represents an undescribed genus of the Ichthyocrinidae but the incompleteness of the specimen, particularly in the interradial areas, makes it unwise to erect a new genus until additional and better material can be found.

Dr. Winifred Goldring, of the New York State Museum, was kind enough to examine the crinoid specimens discussed in this paper. The writer wishes to acknowledge her helpful suggestions with deep appreciation.

Order **Camerata** Wachsmuth and Springer

Family **Rhodocrinidae** Roemer

Gilbertsocrinus ohioensis n. sp.

(Plate I, figs. 1–4)

Description.—This species is represented by two imperfectly preserved specimens, the combined characters of which are sufficient to demonstrate its distinctiveness from any previously described species of the genus.

The measurements of the two dorsal cups which have somewhat different proportions are: height to arm bases 10 mm., greatest width about 14 mm. at the arm bases; height to arm bases 8 mm., greatest width 8 mm. at the first primibrachs. Cup somewhat cylindrical in outline and pentagonal in cross section; the smaller specimen is noticeably restricted between first primibrachs and arm bases.

Basal pit wide, of moderate depth, enclosed by basals and lower half of the radials. Although infrabasals are present their general shape and character cannot be determined definitely. Basal plates large, hexagonal in outline, extending wedge-like between the lower half of the radials and forming the re-entrant angles. Radials are the largest plates in the cup, heptagonal in outline, the surface extended into large conspicuous spines. First primibrachs about as high as the radials, hexagonal in outline; primaxils only slightly lower than the first primibrachs, heptagonal in outline.

Primary interbrachials somewhat larger than first primibrachs, hexagonal in outline, extending for half their length between the radials, and resting on the truncated basals below. In four of the interradial areas the primary interbrachial is apparently followed by four rows of interbrachials composed of the series 3, 3, 2, 2. The succession of plates in the posterior interradial area has not been determined.

Secundibrachs 2 x 10. The second is axillary; on its inner side an arm arises, and on its outer an interradial appendage. Intersecundibrachs not determined. Each arm bifurcates on the fourth or fifth secundibrach, the inner arm again on the third tertibrach, giving three arms to the half ray or six to the ray. These have been determined from two rays only, the others are not sufficiently well preserved to be accurately counted.

Arms ten, short, zigzag biserial, with long pinnules.

The character of the tegmen cannot be definitely determined. However it appears to be low as is characteristic of most other species of the genus, and is composed of numerous small nodose plates. Interradial tubular appendages are formed from single series of cylindrical discs; evidently not recurved.

Column round, 2 to 2.5 mm. in diameter; axial canal large.

The ornamentation is the type distinctive of other species of the genus. Long blunt spines are present on all the radials. A radial ridge extends from the base, forking on the primaxil. On the first primibrach it is modified into a low, rounded node. All of the interradial plates, with the exception of the primary interbrachial, have distinct nodes at the center. These are connected by low ridges which define rhombic outlines on the surface of the plates. Nodes are also present on the tegmen plates but their character and distribution cannot be definitely determined.

Remarks.—The two specimens upon which this species is based consist of two dorsal cups, one of which has a portion of the arms preserved. One is larger and more robust than the other, but details of surface sculpture and other features seem to be identical and thus justify inclusion in the same species. The form is of much interest because it adds yet another variant to the interesting assemblage of species of *Gilbertsocrinus* of middle Devonian age.

The lack of strong nodes on all but the radials seems to be the outstanding feature of the species. In this respect it resembles *G. rarispinus* Goldring, but differs in having strongly developed radial ridges, and less prominent ridges connecting the nodes in the interradial series. From *G. spinigerus* (Hall) it differs in the absence of spines on the primary interbrachial, and in having biserial rather than uniserial arms. It may be separated from *G. greenei* by the absence of spines on both primary interbrachials and first primibrach. From *G. alpenensis* Ehlers it differs in the absence of spines on the first primibrach. The arm arrangement is very much like *G. intersculptus* Goldring but there are no spines on the primibrachs.

Horizon and Locality.—Silica shale, middle Devonian, probably lower ten feet, quarry Sandusky Lime and Cement Company, Silica, Lucas Co., Ohio.

Family **Hexacrinidae** Wachsmuth and Springer

Arthracantha carpenteri (Hinde)

(Plate I, fig. 5)

A very fine specimen of a young *Arthracantha carpenteri* (Hinde) in Mr. Ladd's collection deserves special mention because to my knowledge only one other specimen has been figured which even approaches it in the completeness and excellence of the arm preservation. The other specimen from the Hamilton shale at Thedford, Ontario, Canada, was originally described and figured by Elvira Wood (7), and later refigured by Winifred Goldring (2). Miss Wood's specimen is evidently a mature'

form and is considerably larger than the Silica shale specimen. The arms have been distorted somewhat, and the upper part is missing, so that the true outline of the crown is not evident.

The Silica shale specimen, on the other hand, has the arms complete to the tips, thus showing the manner of infolding at the distal end. Although it is crushed on one side, the original outline of the crown is intact, and apparently has not been impaired in any way.

The larger Ontario specimen has longer arms with more frequent bifurcations. At least three bifurcations occur above the primaxil and probably a fourth, since the upper portion of the crown is incomplete.
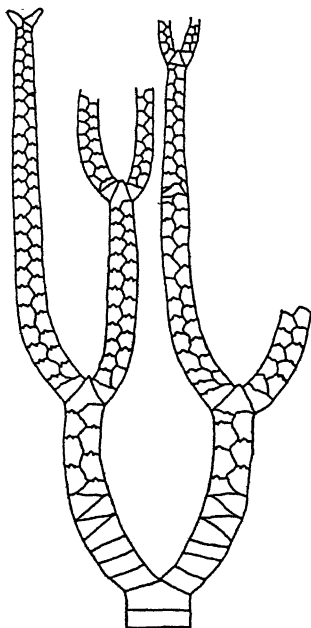
Fig. 1. Analysis of plate arrangement in left anterior arm of
Arthracantha carpenteri (Hinde).

The Silica shale form, on the other hand, has just two bifurcations above the primaxil on all but one arm, where a third division can be seen very close to the tip.

A noteworthy feature of the Ohio specimen is the strong development of the distally pointing tubercles on the axillaries, which seem to be proportionately stronger than in Wood's specimen. They are extended into short spines, one on the secundaxil, and two on the tertaxil. Here and there, with no definite arrangement, a large, strong tubercle is developed between bifurcations. In all other respects the detail of the arms seems to be identical with the Canadian specimen as also are the details of the dorsal cup.

Fig. 1. *Horizon and Locality.*—Silica shale, Kelley's Island Lime and Cement Company quarry, Silica, Ohio.

<div align="center">

Order **Flexibilia** Zittel

Suborder **Sagenocrinoidea** Springer

Family **Ichthyocrinidae Angelin** (em. W. and Sp.)

Euryocrinus ? **laddii** n. sp.

(Plate I, fig. 6)

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Description.—A medium sized species, with an elongate, more or less ovoid body, the arms infolding distally. A fairly complete laterally compressed crown measures 37 mm. in height, and 7 mm. in width at the base of the cup, increasing in width to 25 mm. at the tertaxils the region of greatest width.

Base of dorsal cup broadly and shallowly concave, pentagonal in outline. The condition of preservation is such that neither infrabasals nor basals can be clearly defined. Apparently three large infrabasals are present entirely surrounded by the basals. Although the actual outline of the basals cannot be accurately determined they are seen to extend in side view in two interradial areas as narrow triangular facets between the radials; the posterior basal appears to be longer than the others and rectangular in outline. Radials wider than high, hexagonal in outline, approximately 4 mm. in breadth at the widest portion just above the middle, and 2.5 mm. in height. Upper margin of radials somewhat arcuate, the lower curving into the edge of the basal facet. Surface smooth except for pronounced vertical and transverse angularities. The vertical angularities form the points of the basal pentagon, the basals making the re-entrant angles.

Primibrachs three, wider than high, the middle one somewhat lower than the other two; first primibrach hexagonal in outline, second somewhat quadrangular, while the primaxil is pentagonal. All three are practically the same width. The dimensions of the primaxil are: height 2.75 mm., width 6 mm.

Anal plate angular, the exact outline not determined with certainty; followed by several series of angular plates whose number cannot be determined. In the other interradial areas at least one row of angular plates is present, extending up to the secundibrachs. In two areas the primary interbrachial has been preserved and is seen to be pentagonal in outline. Unfortunately most of the plates in the interradial series have been destroyed in the cleaning so that their character is not certainly known.

Arms dichotomous, bifurcating on the third secundibrach; secundibrachs somewhat narrower than primibrachs and higher in relation to the width. One large intersecundibrach may have been formerly present but has not been determined definitely. First secundibrach pentagonal, second somewhat quadrangular, while the secundaxil is pentagonal and slightly higher than the others. The second bifurcation takes place in the seventh tertibrach on the outer branch, and in the fourth on the inner branch; from the first tertibrach the arms abut, just how high cannot be determined with accuracy. Plates are short and wide and

interlock laterally by angular margins with prominent ridges. Succeeding brachials narrow and high. The third bifurcation takes place on the twelfth quartibrach in the outer branch, and on the seventh quartibrach in the inner. The intervals of bifurcation above this cannot be determined.

Column not preserved, but judging from the size of the basal facet it was evidently large.

The only ornamentation consists of the angularities on the radial and lower brachials and the angular ridges at the margins of the interlocking plates.
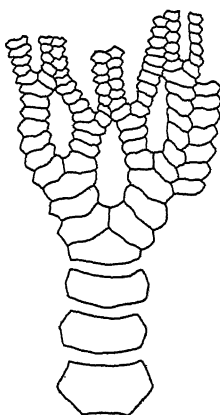
Fig. 2. Analysis of right posterior ray of *Euryocrinus ladii* n. sp.

Remarks.—This interesting form is represented by one incomplete crown. Its characters are sufficiently striking to justify separation from all described species. It is placed provisionally in *Euryocrinus* with which genus it seems to agree more closely than any other genus of the Ichthyocrinidae. It differs, however, in the higher incorporation of the brachial plates in the dorsal cup which includes to at least the secundibrachs and probably beyond; and the anal series of plates are much more numerous. Other genera of the Ichthyocrinidae of Devonian age which have resemblances in common with the form under consideration are *Clidochirus*, *Synaptocrinus*, and *Dactylocrinus*. However, all three of them have only two primibrachs, while this form has three. From *Clidochirus* it can further be separated in the presence of interradial plates in all of the interradial areas instead of just the posterior, and in the absence of a radianal plate. *Synaptocrinus* lacks plates in all the interradial areas, and *Dactylocrinus* has a different arm arrangement above the secundibrachs.

Evidently only one other species of the genus *Euryocrinus* has been recognized in Devonian rocks in North America, *E. barrisi* Springer. This species is represented by two calices from the Traverse group of the middle Devonian at Partridge Point near Alpena, Michigan, and a more complete specimen from rocks of Hamilton age at New Buffalo,

Iowa. *Euryocrinus ? laddii* n. sp. may be separated from it not only by the generic differences just discussed but also by the different shape of the crown, the absence of nodose projections at the margin of the brachials, and the less sharply angular rays.

Additional and better preserved material will no doubt necessitate the separation of this form under a new genus.

The species is named in honor of V. E. Ladd, of Toledo, Ohio, who kindly loaned the specimen to the writer for study.

Fig. 2. *Horizon and Locality.*—Silica shale, probably lower ten feet, Kelley's Island Lime and Cement Company quarry, Silica, Ohio.

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EXPLANATION OF PLATE I

(All figures magnified ×2)

Gilbertsocrinus ohioensis n. sp.

Fig. 1.   Lateral view of specimen showing strong development of radial spines and proximal portion of arms.

Fig. 2.   Basal view of same specimen.

Fig. 3.   Lateral view of larger specimen showing the forking of the radial ridge on the primaxil, and the arm bases.

Fig. 4.   Basal view of same specimen.

Arthracantha carpenteri (Hinde)

Fig. 5.   Right posterior view of specimen showing especially well the manner of arm bifurcation and the strong development of blunt spines on the arms.

Euryocrinus ? laddii n. sp.

Fig. 6.   Right posterior view of crown showing character of dorsal cup and abutting arms. In the lower right interradial area one plate of the interradial series is visible.
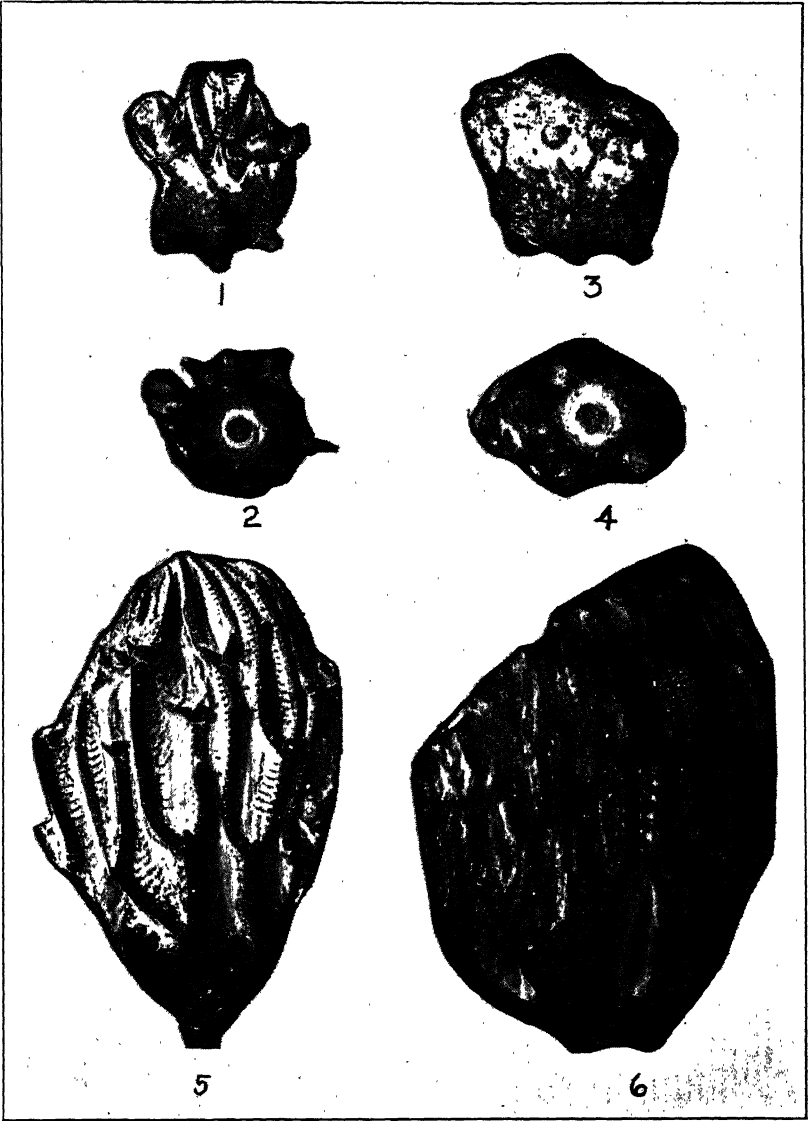
THE MECHANISM OF DRUG CONTROL OF GASTRIC MOTILITY[1]

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Recent clinical investigation has demonstrated the significance of the motor behavior of the human stomach during certain pathologic states. Hoffmeister, Cannon, and Magnus (30) were among the first investigators to recognize this physiologic principle. Their studies of gastric motility led to investigations of the emptying time of the stomach and the effect of denervation operations on the activity of the stomach. Most of the early studies were conducted on animals and the results obtained lacked uniformity. More recently, members of the Department of Research Surgery of the Ohio State University have had the opportunity to study gastric motility in the human subject.

Barron and Curtis (1) found that following bilateral splanchnic resection there ensues increased motility of the human stomach, while after subdiaphragmatic resection of the left vagus (2) there follows a decreased motility. Veach (36) and Veach, Lauer, and James (37) found that movements of the normal as well as the pathologic human stomach could be controlled by various drugs. Morphine was predominantly motor to the human stomach, while atropine was constantly inhibitory. Prostigmin administered alone was inhibitory to the human stomach, but when administered in conjunction with atropine it became motor.

Recently these investigations in clinical physiology have been put to clinical tests in the management of postoperative gas pains and nausea, the control of the pain of biliary colic, and the relief of certain of the symptoms of obstructive duodenal ulcer. Nevertheless, valuable as is the application of these findings from a clinical standpoint, the factor of fundamental importance is the nature of the mechanism of control of gastric motility.

Under the older theories, visceral motility was thought to be the result of a balance between the activities of the

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sympathetic and parasympathetic divisions of the autonomic nervous system. Accordingly, the motor response of the stomach, following administration of any certain drug, would be the result of stimulating or inhibiting one or the other of the two autonomic divisions, and thus upsetting the balance between these two forces.

However, McCrea (29), McSwiney and Wadge (31), Barry (3), and Harrison and McSwiney (24) have by the use of experiment shown the presence of motor and inhibitory fibres in both the vagus and splanchnic nerves. Gayet, Minz, and Quivy (23) have recently supplied further confirmation of these observations by demonstrating the release of acetylcholine following stimulation of the splanchnic nerve. These investigators have demonstrated that the effect of stimulation of the cut end of either the vagus or the splanchnic may result in either increased activity or inhibition of the stomach; moreover, the result appears to depend largely on the existing degree of gastric *tonus* present at the time of stimulation.

However, it appears to be clear that the vagi are predominantly motor to the stomach while the splanchnics are predominantly inhibitory.

Further evidence of the inadequacy of the older theory postulating the dependence of visceral motor function on a balance between the sympathetic and parasympathetic divisions, is furnished by the recent work of Dale (15, 16, 17, 18, 19, 20), Loewi (26, 27), and Cannon (10, 11, 12, 13). Dale investigated the chemical transmission of the nervous impulse and eventually formulated the adrenergic-cholinergic theory of balance. Since his work, together with the fundamental investigations of Loewi and Cannon, have provided the principal background for the present concept of the control of visceral motility, these studies will be briefly reviewed.

THE CHOLINERGIC DIVISION OF THE AUTONOMIC NERVOUS SYSTEM

Elliott (16) in 1904 observed the similarity between the action of adrenalin and the stimulation of the "true" sympathetic nerves. Dixon (16) in 1906 argued that the parasympathetic nerves similarly release a chemical transmitter of their effects. The same year Howell (16) suggested that inhibition of the heart by vagus impulses is due to mobilization of potassium ions.

In 1921 Otto Loewi (26) stimulated the vagus to an isolated frog heart, removed the saline from the chamber, and something in the fluid inhibited a second frog heart. This proved the liberation of a specific chemical stimulator in the transmission of a peripheral autonomic stimulus. Later, Loewi (16) showed his "Vagusstoff" to be identical with acetylcholine in obtaining certain biological reactions.

Sir Henry Dale in 1933 (15) showed that when the sympathetic nerves of the sweat glands are stimulated, acetylcholine is produced. Therefore, he suggested a reclassification of the autonomic nervous system into adrenergic and cholinergic fibres, which on stimulation will produce adrenine or acetylcholine. Later work (16) has shown that all preganglionic fibres and most postganglionic fibres are cholinergic; the only adrenergic nerves are the postganglionic fibres of the "true" sympathetic nerves. Dale (17) believes that a propagated nervous impulse releases a wave of mobilization of potassium ions along a nerve fibre; this process arrives at the ending of a preganglionic fibre and there immediately liberates a small charge of acetylcholine, which causes the discharge of a new impulse, with perhaps a new wave of potassium mobilization passing along the postganglionic fibre. He believes that the excitatory impulse is actually transmitted across a synapse by the liberation of acetylcholine. Dale suggested in 1914 (18) that this is possible within the reaction time if acetylcholine were circulating in the blood in an inactive state, perhaps as choline, and when made active by its ester, is immediately inactivated by some substance, as cholinesterase. This suggestion was supported in 1936 in the course of further studies by Dale, Feldberg, and Vogt (19).

The majority of Dale's investigations have been confirmed and accepted by other students. Lehnartz (25) in 1936 found a similar mobilization of potassium ions could be produced by stimulation of the vagus with acetylcholine. Bureau (9) reports a detectable increase of potassium ions following electrical stimulation of frog muscle immersed in Ringer's solution.

If the nervous impulse is transmitted by acetylcholine, the origin of this substance is of importance. Recently considerable evidence has pointed to the presence of a precursor of acetylcholine in certain tissues. Dikshit (21) finds that

in the presence of eserine, acetylcholine is formed by thin slices of the brain of the dog and rabbit. Corteggiani (14) finds that the brain, spinal cord, nerves of many vertebrates, the vagus of the dog, and intestine of the hedgehog contain quantities of acetylcholine which can be liberated on heating. Pinotti (34) noted that the fibres of the vagus contain acetylcholine in the inactive state. These findings add weight to the conclusions of Brown and Feldberg (6) who believe acetylcholine is mobilized from a preformed store by immediate synthesis upon the arrival of the nervous impulse.

The theory of the production of acetylcholine as the substance of transmission of nervous impulses in muscle contraction also implies its extremely rapid disintegration. This extraordinary evanescence of action of acetylcholine was noted by Dale in 1914 (18) and he suggested at that time that it was probably hydrolyzed with great rapidity by an esterase in the blood. This has been confirmed by Marnay and Nachmansohn (28) who noted that the concentration of cholinesterase at the nerve end plates in the frog sartorius is many times that found in nerveless muscle tissue. This enables the muscle to split the acetylcholine liberated by nerve impulses during the refractory period. The chemical changes can occur with the rapidity necessary for the assumption of a chemical transmission of nerve impulses in such quickly reacting cells as fibres of voluntary muscle. However, owing to technical difficulties, it has not been possible to isolate cholinesterase, or to assay its activity at parasympathetic endings.

Clinicians who have used acetylcholine are struck by the uncertain and variable results following subcutaneous or intravenous injection of the substance. This is interpreted as due to the remarkable evanescence of acetylcholine, because of its rapid hydrolysis by the cholinesterase present in the blood and tissues. Fraser (22) found that subcutaneous injection of acetylcholine in man is usually without apparent effects, and even when introduced intravenously no effect is obtained if the blood is allowed to flow back into the syringe. It is therefore probable that following the arrival of the impulse at the nerve endings, acetylcholine is produced, transmits the effect of the impulse, and is almost immediately destroyed by the cholinesterase present locally in the tissue.

THE ADRENERGIC DIVISION OF THE AUTONOMIC
NERVOUS SYSTEM

Cannon and Bacq (11) in 1931 elaborated Elliott's original finding and proved that any smooth muscle when affected by sympathetic impulses gives off a hormone, which when reinjected into the blood stream, will increase the blood pressure and heart rate. This hormone was named "Sympathin" and at first was thought to be identical with adrenalin.

However, Cannon and Rosenblueth (12), investigating this sympathetic substance in 1933, concluded that sympathin was not identical with adrenalin. Further they postulated the formation of two forms of sympathin. Sympathin E, which is formed when the action is excitatory, and Sympathin I, which is formed when the action is inhibitory. In addition they postulated a mediator M; thus the local effect is produced by the combination of M with E or I to form ME or MI.

It appears to be established that by whatever means the nervous impulse is transmitted, acetylcholine is produced at or near the end plate of the cholinergic nerve. The effect is then transmitted to the smooth muscle cell, and the acetylcholine is almost immediately hydrolyzed by cholinesterase. Sympathin is likewise produced at or near the end plate of the adrenergic nerves. Thus the activity of the organ involved by autonomic stimulation is the result of an interaction between acetylcholine, cholinesterase and sympathin. (Chart 1.)

Myerson (32) summarizes the opinion of many investigators when he calls attention to the inadequacy of even this concept of balance to explain all autonomic functions. However, investigators at present agree that visceral activity depends on a chemical balance. Therefore, the present concept of the activity of drugs on smooth muscle will be reviewed. (Chart 2.)

Acetylcholine, mecholyl (acetyl-beta-methylcholine-chloride), adrenalin, and benzedrine sulphate are believed to act directly on the smooth muscle fibre. Dale (17) noted a two phase reaction of acetylcholine following injection of the substance into smooth muscle. Brown and Harvey (7) repeated the arterial injection of acetylcholine into avian muscle. Raventos (35) injected acetylcholine into the tibialis artery of frogs. All these observers agreed that the action of acetylcholine was first at the end plate, and second on the muscle itself. Buchthal and Lindhard (8) noted that the thoracic muscle of the lizard

will contract when acetylcholine is applied directly to the muscle.

Elliott (16) in 1904 noted that after the sympathetic fibres had been cut and had degenerated, the structures previously innervated by them responded in a characteristic manner to adrenine. Nachmansohn (33) believes the action of adrenalin is on the muscle itself, independently of the nervous system, since adrenalin accelerated glycolysis in chopped muscle.

Finally, Cannon and Rosenblueth (13) showed that smooth muscle cells, completely deprived of their autonomic innervation, will react in the usual manner to adrenalin.

Chart 1.—Balance between sympathetic and parasympathetic nerves and esterase.
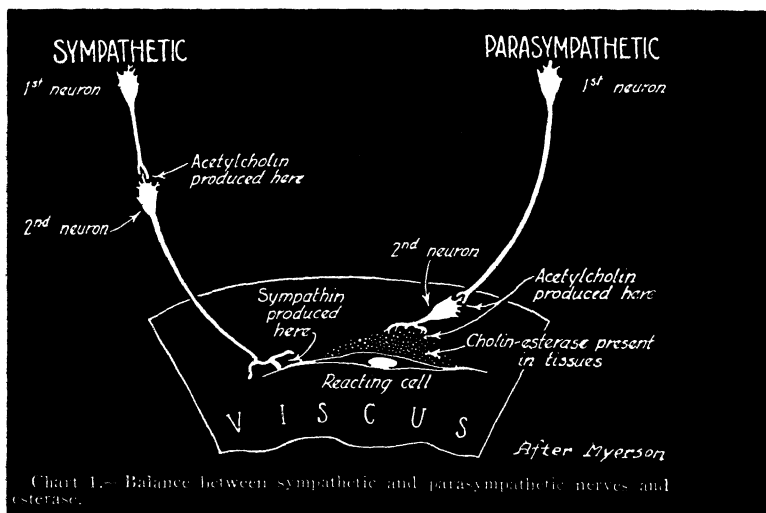
Bozler (4) draws attention to the protoplasmic connections existing between certain smooth muscle cells and states that after stimulation, an isolated strip of visceral smooth muscle acts as a single cell, following the "all or none" law. He believes that adrenalin decreases the excitability of the muscle; thus there is a resultant action of the muscle which appears to be due to the drug.

From these somewhat conflicting views, Myerson (32) has summarized the present concept of the action of drugs on smooth muscle. (Chart 2.) Atropine sulphate, physostigmine, and the commercial preparation of similar properties, Prostigmin, are believed to act in the region of the parasympathetic

end plates.   Atropine in some unknown fashion blocks the action of acetylcholine.   This it does, probably not by paralyzing the vagus, but by inhibiting the effect of acetylcholine on the cell of the effector organ either by a direct chemical block of acetylcholine or by enhancing the action of cholinesterase in such a fashion that acetylcholine is hydrolyzed more rapidly. In any case, by neutralizing or removing the cholinergic factor, atropine acts as a synergist to the adrenergic factor.

Prostigmin enhances the action of acetylcholine at the parasympathetic end plate.   This is accomplished either by

Chart 2.—Working hypothesis of human autonomic pharmacology.
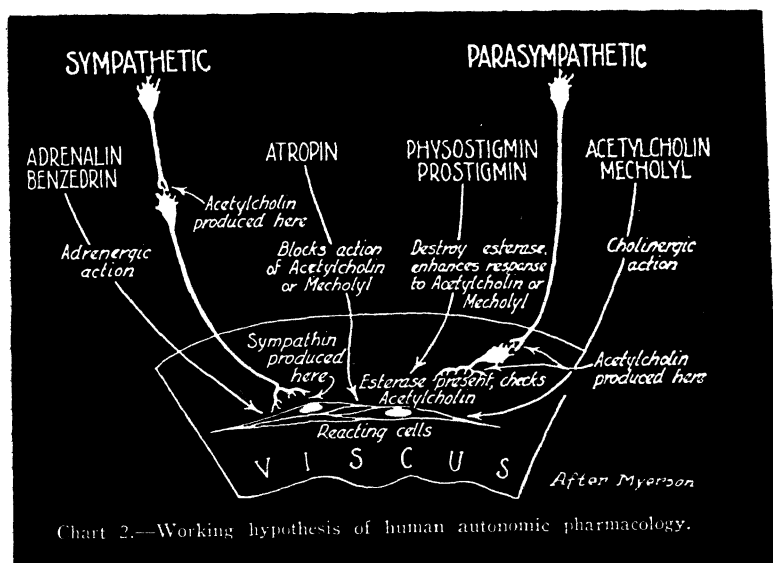
Prostigmin entering into direct chemical union with acetyl-choline so as to stabilize it, or by destroying esterase, thus delaying the hydrolyzation of acetylcholine.

This explanation of drug action, although it is accepted at present by many physiologists, does not adequately explain some of the clinical effects we have observed during investigation of the motor activity of the human stomach.   In our investigations (37), Prostigmin administered alone inhibits the motility of the human stomach, but when administered in conjunction with atropine a motor effect is observed.

Recent work (5) indicates that drugs may have a more intricate action than is generally believed.   The drugs whose

action is dependent upon the production of acetylcholine are believed to act simultaneously wherever acetylcholine is produced. Thus Prostigmin stabilizes the production of acetylcholine at the cholinergic end plate. However, it also stabilizes the production of acetylcholine at the sympathetic ganglion, when acetylcholine is produced to transmit the nerve impulse from the preganglionic to the postganglionic sympathetic fibre. Stabilization of the production of acetylcholine at the sympathetic ganglion would result in stimulation of the postganglionic sympathetic fibre, which would result in the production of a larger amount of sympathin at the adrenergic end plate. If this latter effect should overbalance the effect of stabilization of acetylcholine at the cholinergic end plate, the clinical effect on the stomach would be inhibition of motility following administration of Prostigmin.

In a similar fashion, atropine blocks the action of acetylcholine at the cholinergic end plate, but it also blocks the production of acetylcholine at the sympathetic ganglion. This would presumably prevent the transmission of the sympathetic impulse, so that a motor reaction could follow the administration of atropine. This is believed to explain the Prostigmin-atropine effect. Following administration of either Prostigmin or atropine, the motility of the human stomach is inhibited by enhancement of the adrenergic factor, but when both drugs are administered the chemical balance swings to the cholinergic side, so that clinically a motor effect is observed.

Recent investigations of the action of ephedrine cast some doubt on the similarity of its action with adrenalin and benzedrine. It may later be proved that ephedrine stabilizes the production of sympathin at the adrenergic end plate in the same manner that physostigmine stabilizes the production of acetylcholine at the cholinergic end plate (5). Further investigation on this subject is contemplated.

The action of morphine is not yet clear. Since this drug has several simultaneous sites of action, it is difficult to determine its autonomic pharmacology. An abundance of literature is to be found on the action of morphine, nevertheless, further investigation appears to be necessary. Clinically, Veach (36) has shown morphine to be predominantly motor to the human stomach. Weiss (38) reports that a number of investigators, Plant and Miller, Gruber and Robinson, Orr, Carlson and

others, have shown that morphine in ordinary doses increases the tone, amplitude and frequency of stomach contractions. Large doses stop peristalsis and decrease the tone, but increase the segmentary movements. In our investigations administration of morphine was followed by hypermotility of the stomach which increased the distress of postoperative "gas pains," late postoperative nausea, biliary colic, and pylorospasm due to obstructive duodenal ulcer. It seems probable that in respect to the stomach, morphine acts either as a synergist to acetylcholine, or inhibits the action of the esterases.

It is obvious that these theories do not explain all the details of autonomic pharmacology. Further investigation is necessary on the mechanism of the action of drugs on smooth muscle. It may be that after sympathin and cholinesterase are isolated, further light will be shed on this perplexing problem.

SUMMARY

According to the humoral theory, the activity of any organ involved by autonomic stimulation is the result of an interaction between acetylcholine, sympathin and the esterases. This concept of balance does not explain all autonomic functions. However, according to the present concept of the activity of drugs, acetylcholine acts on the smooth muscle cell, and is hydrolyzed by cholinesterase. Prostigmin enhances the action of acetylcholine, either by entering into direct chemical union with acetylcholine so as to stabilize it, or by destroying esterase, thus delaying hydrolyzation of acetylcholine. Atropine, in some fashion, blocks the action of acetylcholine. This it does, probably not by paralyzing the vagus, but by inhibiting the effect of acetylcholine on the cell of the effector organ. Loewi and Navratil (27) showed that although atropine inhibits the effects of vagal stimulation to the frog heart, it does not prevent the production of acetylcholine at the nerve endings. In any case, by neutralizing or removing the cholinergic factor, atropine acts as a synergist to the adrenergic factor. Benzedrine appears to act as adrenalin, directly on the smooth muscle cell.

Most drugs that affect the autonomic system simulate the effect of stimulation of the cholinergic or adrenergic nerves, although the mechanism of action in many cases is quite different. It is generally believed that the primary seat of action of certain drugs, such as adrenalin and acetylcholine, may be in the region of the end plate, directly on the smooth

muscle cell. In such a case, the action of the drug is independent of the nerve supply. Other drugs, such as atropine and physostigmine, are concerned with the nervous innervation of the muscle, and the customary action would appear to be dependent upon an intact nerve supply.

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Microbes and Men

Considerable objection can be raised to the title of this book if its purpose is to point out the importance of the microbes to human welfare. The all too prevalent idea that bacteria are important only insofar as they produce disease is one the biologist would like dispelled. Fortunately the author has written a book broader in viewpoint than the title would indicate. The book is well-balanced and accurate, the illustrations well-chosen, and the subject matter ably presented. It contains a good glossary and has an index. Since it is designed for the general reader and not for use as a text the jargon of the bacteriologist is avoided as much as possible. I am afraid, however, that the general reader may still find it difficult to appreciate much of the discussion. Somehow the book lacks fire.—*J. M. Birkeland.*

Man Against Microbes, by Joseph W. Bigger. 304 pp. New York, the Macmillan Co. 1939. $2.50.

THE DEVELOPMENTAL HISTORY OF GERMARIA IN PARTHENOGENETIC FEMALE APHIDS[1]

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INTRODUCTION

That germaria play a significant role in determination of differential features between gamic female and parthenogenetic female ovarioles of the aphid *Macrosiphum solanifolii* was suggested by Lawson (1939b). The ovarioles of both types of females consist of a tubular vitellarium on the end of which is attached a spherical germarium containing nurse cells and germ cells. The germ cells in both types of ovarioles descend from the germarium into the vitellarium where development occurs, but the development of germ cells in gamic female ovarioles differs from the development of germ cells in parthenogenetic female ovarioles. In the vitellarium of a gamic female ovariole the eggs grow large by the accumulation of much yolk, presumably undergo meiosis and require fertilization and deposition before embryonic development can occur. In the vitellarium of the parthenogenetic female ovariole the germ cells are stimulated to develop parthenogenetically into embryos which are born alive upon reaching the proper stage of development. The fundamental difference between the two types of ovarioles is the difference between the two types of germ cells that develop within the ovarioles. These germ cells are produced by the germaria and, according to the theory proposed by Lawson, each germarium determines the subsequent development that its germ cells shall undergo. Other differences between parthenogenetic female and gamic female ovarioles are supposedly secondary to the germ cell difference and are determined also by the original differentiation between germaria.

If the germarial theory is correct it also should explain the production of (1) structures other than ovarioles which differentiate gamic and parthenogenetic females, (2) aphids intermediate between gamic and parthenogenetic females, (3) winged

and wingless parthenogenetic females, and (4) aphids intermediate between winged and wingless parthenogenetic females. These forms are interrelated in such a way that variations in the same mechanism must be responsible for the production of all.

The first step in a study of the relation of germaria to determination of various aphid types is an understanding of the developmental history of the germaria in the parthenogenetic female aphid. This paper is an attempt to lay such a foundation.

FIRST APPEARANCE OF GERMARIAL CELLS

There is a stage in the development of a parthenogenetic female aphid embryo shortly after the germ band is formed when one end of the embryo opens to allow "symbionts" or "mycetocytes" to enter. The symbionts fill the entire central cavity of the blastula shaped embryo with the exception of a small space immediately dorsad of the germ band. Lying in this space between the germ band and the symbionts is a group of cells whose descendants make up the germaria (fig. 1). Each of these cells has a large nucleus with a very thin layer of cytoplasm around it. The nucleus contains a prominent nucleolus and either a number of chromosomes that appear split longitudinally in preparation for mitotic division or a thick, heavily staining late prophase strand. The cells are larger than any other cells in the embryo except those cells that become hosts for the symbionts. These host cells can be distinguished from the germarial cells by virtue of their containing chromatin in a very thin lightly staining spireme.

The group of cells that have been designated "germarial cells" could also be called "germ cells" in contrast to the somatic cells which make up the rest of the embryo. However, as all of the original group of cells do not become reproductive cells it is thought best to use "germarial cells" for the cells in early stages of development and to reserve "germ cells" for the actual reproductive cells that differentiate later.

IDENTIFICATION OF GERMARIAL CELLS IN EARLY
EMBRYONIC STAGES   •

During the early stages of development which precede revolution of the embryo the germarial cells lie in a compact group at the posterior end of the embryo, surrounded by a thin epithelial membrane. The cells can be recognized easily by their size, which is usually greater than adjacent somatic cells, and by the nature of their nuclei which usually contain chromatin in various prophase stages. A further mark of recognition is the position of the germarial cells in relation to the symbionts. These symbiotic cells collect at the posterior end of the embryo during early developmental stages. Lying next to them and sometimes partially surrounded by them are the germarial cells.

EARLY DEVELOPMENT OF THE GERMARIAL CELLS

Though the germarial cells are isolated somewhat from the somatic cells of the embryo, they go through a series of developmental stages which parallels the development of the soma. A series of mitotic divisions occurs in the germarial cells between the germ band stage and the revolution of the embryo. Metaphase stages are occasionally observed while prophase stages are common. During this period of mitotic division the germarial cells are evidently segregated into groups for whenever metaphase stages are observed they occur in groups of adjacent cells only and not in the entire group of cells. The cells not in metaphase exhibit the more common prophase stages.

Fig. 1. Longitudinal section through an aphid embryo at stage of development of germ band. GB—germ band, GC—germarial cells, S—symbionts.

FORMATION OF GERMARIA

A change in the germarial cells that is evident at least as early as the formation of appendage buds in the soma is an increase in the cytoplasm of each cell. This cytoplasm does not form evenly around the nucleus but concentrates at one side forming a blunt, cone-shaped tail. At about the same time that the cytoplasmic cone is formed on each cell, the cells are arranged more or less loosely into a number of spherical groups. In each sphere of cells the nucleus of each cell lies near the periphery and the cytoplasmic cone lies between the nucleus and the center of the sphere. In a cross section of such a group the nuclei form a ring in the center of which is a circular area of cytoplasm made up of

several cytoplasmic cones lying side by side. Metaphase stages of cell division have been observed in these spheres of germarial cells. Either shortly before or during the revolution of the embryo each group of germarial cells becomes surrounded by a thin epithelial membrane and henceforth can be called a germarium.

POSITION OF THE GERMARIA

The position of the germaria relative to the rest of the embryo is changed during the revolution of the embryo. Prior to this event the germaria, or in early stages the germarial cells, are found at the posterior
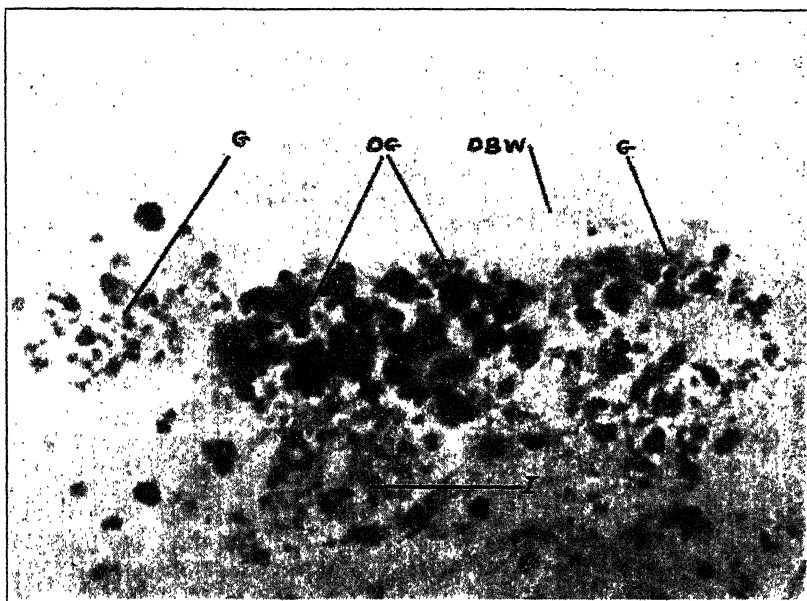
Fig. 2. Cross section through dorsal half of aphid embryo at a stage before dorsal body wall is fully developed. DBW—dorsal body wall, DG—degenerating germaria, G—germarium, I—intestine.

end of the embryo in close contact with the symbionts and in a sense outside of the body of the embryo. After the revolution of the embryo the germaria and the symbionts are located within the newly formed abdominal cavity. At this time the embryo has developed a head, thorax, appendages and a body wall. The body wall, however, is incomplete on the dorsal side of the abdomen, so that here the abdominal cavity opens directly to the outside. The germaria lie just within this opening forming a plate-like group of cells which extends from one lateral side of the abdomen to the other and from near the anterior end of the abdomen to near the posterior end. Immediately ventrad of the germaria are the symbionts which fill the greater part of the abdominal cavity.

DEGENERATION OF MID-DORSAL GERMARIA

Several groups of germaria which lie in the mid-dorsal region of the abdominal cavity degenerate after revolution of the embryo and before the dorsal body wall closes (fig. 2). During this degeneration the cells round up, become smaller than other germarial cells and stain an intense black with iron-hematoxylin. These cells are completely gone by the time the dorsal body wall closes.

After the degeneration of the mid-dorsal germaria two sets of germaria remain, one on each lateral side of the abdominal cavity. One group usually contains five germaria and the other contains four or occasionally five. This is the number and arrangement of germaria in older more fully developed embryos.

DIFFERENTIATION OF NURSE CELLS AND GERM CELLS

The germarial cells differentiate into two types of cells, nurse cells and germ cells, sometime during embryonic development between the germ band stage and closure of the abdominal wall. The exact time that this differentiation takes place is difficult to ascertain because of the similarity between the two types of cells. A distinction can be made after the germaria are fully formed, for the nurse cells then are grouped in a sphere, while the germ cells lie at the posterior end of the germarium between the ball of nurse cells and the epithelial covering of the germarium. Prior to the formation of the germaria the nuclei of the cells occasionally exhibit different prophase configurations, but this does not differentiate the two types of cells. The cytoplasm of the germarial cells becomes cone shaped before germaria are fully formed, and it was thought that the presence of such cones on certain cells would identify them as nurse cells, while the absence of such cones on other cells would identify them as germ cells. No such distinction could be made with certainty, though it may exist. Differing sizes of cells as a criterion is equally uncertain, for nurse cells sometimes vary in size within the same germarium and, also, in different germaria.

DEVELOPMENT OF THE OVARIOLES

After the formation of the germaria the epithelial covering of each germarium grows back as a small cellular tube in a posteriad-ventrad direction toward the region where the vagina later develops. These backward growing cellular tubes are the ovarioles or more precisely, the vitellarial region of the ovarioles. There are two groups of ovarioles, one for each lateral group of germaria. The ovarioles in each group unite a short distance behind the germaria to continue toward the vaginal region as a single tube which becomes the oviduct of the adult. As there are two groups of germaria, and two groups of ovarioles there are likewise two oviducts. In adult anatomy the ovariole includes the epithelial covering of the germarium and the tube that leads from the germarium to the oviduct, while the vitellarium refers only to that part of the ovariole that leads from the germarium to the oviduct.

PARTHENOGENETIC DEVELOPMENT OF GERM CELLS

Following the establishment of the ovarioles, the germ cells begin parthenogenetic development. This development begins at about the same time that the first faint indication of pigment appears in the eyes of the embryo. Usually one germ cell in each germarium begins to grow through an increase in the amount of cytoplasmic material (fig. 3). The probable source of this additional material is the ball of nurse cells, for with the beginning of germ cell growth, a stream of substance is evident extending from the center of the ball of nurse cells into the growing germ cells. This stream maintains contact with the oöcyte

Fig. 3. Cross section through dorsal half of aphid embryo showing a longitudinal section through two germaria. GC—germ cell, NC—nurse cell, OV—ovariole (vitellarium).

until cleavage is well under way. The exact nature of this substance is uncertain, though a nutrient function is indicated. In a previous publication (Lawson 1939b) the secreted substance was called "yolk" and the stream or thread extending from the nurse cells to the growing germ cell was called a "yolk-stream." This choice of terms may be unfortunate for there is no certainty that the substance is yolk. Growth of the germ cell continues within the germarium until the germ cell has. about tripled its size when it moves downward into the vitellarium. This germ cell or oöcyte, as it may now be called, continues to increase in size, throws off a polar body, and begins cleavage. After cleavage begins another germ cell grows, slips into the vitellariuḿ and goes.

through the same developmental stages as the first cell. A third cell follows the second into the vitellarium before the embryo is born, so that in the oldest embryos each vitellarium commonly contains one growing oöcyte, one egg in early cleavage and one in late cleavage.

POSSIBLE SIGNIFICANCE OF GERMARIAL ACTIVITY

The determination of the winged or wingless condition in the adult aphid occurs before birth (Shull 1928). Hence, if the germarial theory is to have any application to wing determination there must be some event in the embryonic development of germaria that directly affects wing development. The initial stimulation of germ cells to parthenogenetic development may be the visible consequence of such an event.

Shull (1938) has shown that wings begin to develop sometime after pigmentation begins in the eyes of the embryo, but before one-fourth of the ommatidia are pigmented. The first indications of germ cell growth appears at the same time that the first faint traces of eye pigment can be seen. Thus, it may be concluded that germ cells are stimulated before wing differentiation begins. Shull (1938) has estimated that wing determination occurs 10 or 12 hours before wing differentiation. That germ cell stimulation likewise occurs 10 or 12 hours before wing differentiation cannot be said, but that it occurs very near this time is possible.

A variation occurs in the time of initial stimulation of germ cells in the various germaria in the same embryo. Numerous cases have been found where two or three vitellaria contain oöcytes while the other vitellaria in the same embryo have none, and in some cases where all of the ovarioles show germ cell activity some of the oöcytes are more advanced in development than others. This variation supports the theory that germaria are determined, develop and function independently of one another, and, furthermore, it suggests a possible mechanism for the germarial control of wing determination.

To correlate germarial activity with wing determination it is necessary to know, at the time of initial germ cell stimulation, whether or not a given embryo is to be winged or wingless. This could not be determined in the embryos used in this study, so the problem must wait until such information concerning the embryos can be obtained. The use of the constant and intermittent light technique described by Shull (1938) should enable us to get this information.

SUMMARY

The developmental history of the germaria in parthenogenetic female aphids is described beginning with the appearance of the germarial cells in the blastula. The germarial cells are arranged in groups, each of which becomes a germarium. All of the germaria that are formed do not persist, for those lying in the mid-dorsal abdominal region degenerate. The remaining germaria form two groups, one on each dorso-lateral side of the abdominal cavity. Within each germarium the cells

differentiate into nurse cells and germ cells. An ovariole grows out from each germarium and connects to the oviduct, and into the vitellarium of each ovariole the germ cells descend, grow and undergo cleavage. The growth of the germ cells is aided by a substance secreted by the nurse cells. The time when germ cells are first stimulated to parthenogenetic development approximates the time when wing determination takes place and the suggestion is made that the determination of the winged or wingless condition in the adult aphid may be controlled by the germaria.

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The Bionomics of Entomophagous Insects

Prof. W. V. Balduf of the University of Illinois has recently published a second volume on the bionomics of entomophagous insects. Part II covers in considerable detail the widely scattered information on the bionomics of entomophagous species of Lepidoptera, Trichoptera, Mecoptera and Neuroptera. One only needs to read the first three chapters (over 100 pages) devoted to predacious Lepidoptera to appreciate the amount of reading and compilation work the author must have done to assemble such interesting and valuable information. An examination of the excellent bibliographies shows that the subject matter was found in numerous and obscure publications in several languages.

A compilation of this type is of outstanding value to anyone interested in biological control or the biology of predacious insects. As valuable as this book will prove to be, most entomologists will look upon it as a library reference book. It is unfortunate that unique books of this character are not purchased more extensively by persons interested in the biology of insects. The reviewer knows from experience that the production of special books, where the edition does not exceed five hundred copies, usually results in a financial loss to the author.

This book consists of 384 8½ x 11 inch lithoprinted pages, equal to 600 pages of an ordinary size book. It contains 228 excellent figures, 21 tables of information and a complete index. The reviewer hopes that a sufficient number of copies will be sold so that the author will not suffer a financial loss. He would like to see the author prepare in the future one or more volumes dealing with entomophagous Diptera and Hemiptera.—*A. Peterson.*

The Bionomics of Entomophagous Insects, Part II, by W. V. Balduf, 384 8½ x 11 inch lithoprinted pages, 228 figures. St. Louis, John S. Swift and Co. 1939. $7.50.

Histology

In this recently revised pocket-sized volume the elementary facts and principles of the whole field of micro-anatomy including the nervous system are presented with little explanatory and illustrative material, and with little reference to histo-physiology. Actually, the work is an epitome of histo-anatomy. The student preparing for an examination should find it useful for rapidly reviewing the subject matter of a course in micro-anatomy.—R. A. Knouff.

Aids to Histology (4th ed.), by Alfred Goodall. Baltimore, William Wood and Co. 1938. $1.25.

THE EMBRYOLOGY AND LARVAL DEVELOPMENT OF THE GOLDFISH (CARASSIUS AURATUS L.) FROM LAKE ERIE

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INTRODUCTION

Osburn (1901) noted that the common goldfish (*Carassius auratus* L.) had escaped from cultivation in some parts of Ohio and as early as 1888 was reported by Henshall as "not rare in the canal basin near Elmwood, Hamilton County." The species has become quite common in Lake Erie in shallow parts, especially bays and creek mouths (Greeley, 1928). It has been reported by fishermen off the north shore at Port Stanley where it is said to attain a length of 14 to 15 inches. The description of its early development has not, however, been included by Mrs. Fish (1932) probably because it is not an indigenous species.

The goldfish and other Cyprinidae have long been used by geneticists, and also by embryologists, for specialized studies in fish development. However, other than the account by Khan (1929) and the illustrations by Dr. F. J. Myers in the volume by Innes (1936) an adequate description of the general features of its embryonic and larval development is lacking. The following account is an attempt to fill this gap since the goldfish is becoming increasingly important not only from the standpoint of the ornamental fish trade, and as an experimental test animal, but also because of its ability to adapt itself successfully to environmental conditions in Lake Erie.

MATERIALS AND METHODS

All of the eggs for this study were obtained from two sources, Squaw Harbor, South Bass Island, Ohio, in the summer of 1938, and the Moore Water Gardens, Port Stanley, Ontario, in the spring of 1939. The latter provided stages from spawning through early cleavage, since in the breeding cages it was possible to obtain eggs very shortly after they had been deposited on the roots or leaves of any convenient floating aquatic plant such as *Potamogeton*, *Valisneria*, or *Chara*.

All observations were made on living material which was

later fixed in Bouin's Fluid and preserved in 70% alcohol for future reference. The eggs were brought into the laboratory while still attached to water plants and small sections of the latter bearing eggs were transferred to finger bowls containing lake water. To simulate natural conditions some were hung over the float in bottles lowered to a depth of six to twelve inches, while others kept in a semi-dark room were subjected to strong sunlight for short periods daily. No discernible differences were evident between those reared under the two conditions.

Larvae after the first five to seven days were kept in an aquarium in aerated water. Food consisted of plankton taken by a fine net from the adjacent region of the lake, and finely ground rice flour.

<div align="center">SPAWNING</div>

Fearnon (1931) states that goldfish begin breeding in their second year and while they may continue to reproduce for six or seven years they yield the maximum number of eggs in their third and fourth years. Khan (1929) found that spawning usually begins early in the spring and occurs at frequent intervals from April to August over a period from 7 a. m. to 10 a. m. Innes (1936) noted that spawning usually starts at daybreak and lasts till mid-afternoon. From early spring it may be repeated every few weeks until early August but the first spawn of the season is the largest. At Squaw Harbor eggs were obtained in segmentation stages about 8 a. m. to 9 a. m. as late as August 17th, 1938. The capsules of the eggs are of a mucilaginous character and adhere readily to aquatic plants to which they are usually attached singly, rarely in twos or threes and at intervals of one-half to one inch.

<div align="center">EMBRYONIC DEVELOPMENT</div>

Characteristics of the egg

The eggs of the goldfish are spherical pale cream-colored globules, 1.25 to 1.46 mm. in diameter, and slightly flattened along the margin of attachment. When first laid the whole surface is adhesive, but this quality is lost as soon as they have become "water hardened" and attached to aquatic plants. Like other fish eggs, those of this species are telolecithal, the heavier yolk lying beneath the cap-like whitish protoplasmic blastodisc which covers the upper surface (fig. 1). A narrow perivitelline space (.1 mm.) separates the yolk sphere from the heavy structureless egg capsule. The cream-colored yolk is rather unique since it appears to be coarsely granular with a rather dense fluid matrix

containing sparsely scattered transparent oil droplets (.01 to .05 mm. in diameter). The latter have a tendency to disappear during later stages of development.

Period of Incubation

Khan (1929) found the hatching period to vary from forty-six to fifty-four hours at 84° F. Innes (1936) reports a hatching period of from four to fourteen days according to temperature. At 70° to 75° F. five to seven days are required. No attempt was made to rear the eggs from Squaw Harbor at a constant temperature, but those kept in the laboratory with an air temperature ranging from 18.5° C. to 29.5° C. hatched in three to four days. Eggs placed in containers and reared in the lake water which was subject to less radical temperature variations (24° C. to 28° C.) required only sixty-four to seventy-two hours. At Port Stanley, following the late cleavage stages, eggs were subjected to a constant temperature of 25° C. and hatching took place in seventy-six hours.

Cleavage Stages

A few minutes after fertilization the blastodisc contracts and forms a white dome on the upper surface of the yolk (fig. 1). In approximately half an hour the first cleavage furrow, a vertical meridional one, appears (fig. 2) forming two large and approximately equal blastomeres. Fifteen minutes later the second cleavage furrow also, a vertical meridional one appears at right angles to the first (fig. 3). Following this, cleavage becomes irregular and in two hours' time the blastoderm is composed of a mass of relatively small but distinct cells (fig. 4). After four hours' development the cells have become relatively smaller owing to rapid cell division, and the margin of the blastoderm has begun to extend slightly farther over the yolk (fig. 5). In each cell the cytoplasm shows a tendency to radiate from the nucleus.

Investment of the yolk by the blastoderm

The blastoderm becomes thinner along its free edge and now commences to grow ventrally to extend over the yolk sphere. By seven hours' of incubation, it has reached the equator of the egg (fig. 6). The advancing rim of the blastoderm stands slightly above the surface level of the yolk. In the nine hours' stage the blastoderm has completely encircled the yolk with the exception of a small spherical blastopore surrounding a plug of yolk.

Differentiation of the Embryo

Ten hours.—The surface view gives no indication of the embryonic axis aside from a slightly opaque area of undifferentiated tissue passing anteriorly along one radius from the margin of the blastopore.

Eleven to twelve hours.—The axis of the fish embryo is visible as a narrow but rather high transparent ridge extending forward from the blastopore, nearly encircling the yolk (figs. 7 and 8), and bounded on either side by the lateral margins of the embryonic shield. The future head region appears as a flat somewhat oval expansion. By twelve

hours three to four mesodermal somites have appeared and the noto-
chord is differentiated as a narrow band of cells lying next to the yolk
substance.
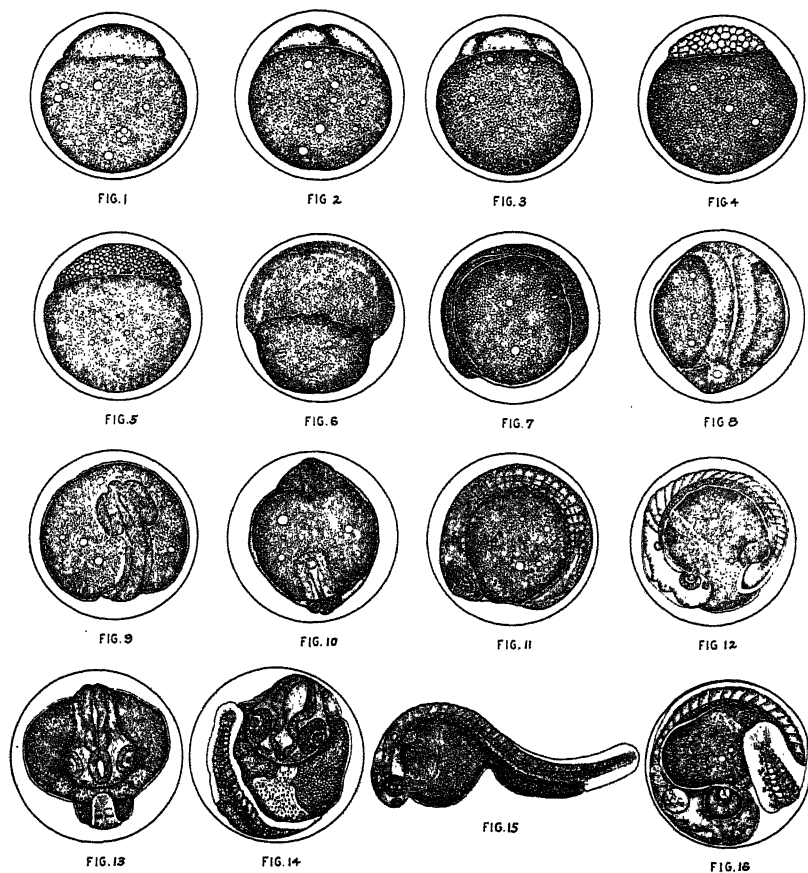
(Drawings by camera lucida)

Fig. 1.   Recently fertilized egg.
Fig. 2.   First cleavage division.   30 mins.
Fig. 3.   Second cleavage division.   45 mins.
Fig. 4.   Many-celled blastoderm.   2 hours.
Fig. 5.   Advanced blastoderm.   4 hours.
Fig. 6.   Yolk mass half overgrown by blastoderm.   7 hours.
Fig. 7.   Early embryo, lateral aspect.   11 to 12 hours.
Fig. 8.   Early embryo, dorsal aspect.   11 to 12 hours.
Fig. 9.   Later embryo with optic vesicles, dorsal view.   15 hours.
Fig. 10.   Later embryo with optic vesicles, ventral view.   15 hours.
Fig. 11.   Embryo of 18 somites.   17 hours.
Fig. 12.   Embryo of 25 somites.   24 to 27 hours lateral aspect.
Fig. 13.   Embryo of 25 somites, dorsal aspect.   24 to 27 hours.
Fig. 14.   Embryo of 32 somites.   45 hours.
Fig. 15.   Embryo of 32 somites removed from egg capsule.   45 hours.
Fig. 16.   Advanced embryo, preparatory to hatching.   65 hours.

Fifteen hours.—Although the blastopore has not yet closed, marked changes have taken place in the anterior axial region (figs. 9 and 10) of the embryo. The brain is clearly visible and the optic evaginations are somewhat oval extending posteriorly from the primary cerebral lobe. Eight to ten somites are present. The embryonic body appears as a thickened ridge and passes by a thin narrow margin to the portion of the blastoderm now one or two cells in thickness, which spreads over the yolk.

Seventeen hours.—The tail reaches almost around to the anterior limit of the head (fig. 11), but the embryo is still adherent to the yolk sac at both ends. Eighteen somites have been differentiated. Auditory vesicles as well as olfactory pits have appeared. The notochord extends as a solid rod of cells from the auditory vesicle to the undifferentiated caudal mass.

Twenty-four to twenty-seven hours. The embryonic body has increased in length, the tail process reaching almost to the anterior limit of the head. Both the head and tail are freed from the yolk surface. A narrow fin fold surrounds the tail and extends forward dorsally to the mid body region (figs. 12 and 13). Distinct contractile movements are evident. Twenty-five somites have been differentiated, but no pigment is visible. The brain is composed of three cerebral lobes, the posterior (rhombencephalon) being elongate with a diamond-shaped ventricle. The optic vesicle has been converted into an optic cup into which the lens has sunken. The notochord is visible as a vacuolated rod extending from the level of the auditory vesicle to the undifferentiated tissue in the core of the tail. The heart has appeared on the anterior surface of the yolk sac as a flattened tube and is pulsating irregularly. The ducts of Cuvier traverse the yolk, passing ventrolaterally from the level of the first few mesodermal somites to the posterior end of the heart. The dorsal aorta is also visible in the trunk region.

Forty-five to fifty hours.—The embryo now forms more than a complete circle around the circumference of the yolk. Its tail lies either to the right or left of the head and is often bent at an angle across the front of the latter. It undergoes rhythmic movements and swims feebly when the capsule is removed with a needle. Small scattered melanophores have appeared on the outer surface of the eye, larger stellate ones over the head and the yolk sac and along the dorsal portion of the body and the primitive intestine (figs. 14 and 15). The brain lobes have increased in size. The yolk sac which has been spherical now consists of an anterior spherical to oval division and a posterior cylindrical portion which terminates at the anus. The pectoral fins appear as fleshy folds lying over the yolk sac at the level of the auditory vesicle. The typical teleostean circulation has been set up at this time. Size measurements are as follows: Total length (head-tail), 2.5; standard length, 2.4; length to vent, 2.0; length of head, 0.70; snout, 0.10; diameter of eye, 0.25; greatest depth before vent, 1.0 millimeters. Myomeres 20 to 22 to vent plus 10 to 12 behind.

Sixty to sixty-five hours.—The embryo has increased considerably in size occupying most of the perivitelline space. Rhythmic movements

occur freely within the egg capsule (fig. 16). Heavy stellate melanophores are massed over the head, the yolk sac, along the dorsolateral musculature, and ventrally over the region of the intestine and ventral musculature. The eye has increased in size and has become densely pigmented. The auditory vesicle is now enlarged and thin-walled, containing two otoliths and the rudiments of semi-circular canals. The dorsal fin fold extends forward to the level of the first somite. The pectoral fins are now free from the yolk surface and are composed of a fleshy base bearing a membranous tip. Removed from the capsule the embryo now resembles the newly hatched larva. Total length 4.4; standard length, 4.2; length to vent 2.9; length of head, 0.78; snout, 0.17; diameter of eye, 0.3; greatest depth before vent, 0.95 millimeters. Myomeres, 21 to 22 to vent plus 11 to 12 behind.

DEVELOPMENT OF THE LARVA AND POST LARVA

Newly-hatched larva (fig. 17.) The larva frees itself by violent lashing movements of the tail which eventually rupture the egg capsule. Total length, 4.5; standard length, 4.3; length to vent, 3.0; length of head, 0.8; snout, 0.17; diameter of eye, 0.3; greatest depth before vent, 0.95 millimeters. Myomeres, 21 to 22 to vent plus 11 to 12 behind.

Pigmentation consists of stellate melanophores located around the jaws, on the dorsal surface of the head, and the whole dorsal aspect anteriorly to the caudal fin. The pigment spots are fewer on the sides of the head and body at the level of the lateral line. There is a heavy subsurface mass of them dorsal to the gill arches, and a double to triple series on the dorsal surface of the intestine extending beyond the vent to the tip of the notochord. The yolk sac bears large scattered melanophores more especially anteriorly. Swimming movements are somewhat restricted owing to the mass of yolk material. The larva shows a positive thigmotropism, adhering to the aquarium walls or any fragments of plants. The heart is differentiating into chambers although it is still almost vertical in position at the anterior end of the yolk sac. Five aortic arches are present. The continuous median fin fold with its preanal portion has already been adequately described by Grimm (1937). The cerebral hemispheres, pineal body, mid brain (optic lobes), cerebellum and medulla oblongata are all clearly distinguishable.

5.8 millimeter stage. (fig. 18). Age 1½ to 2½ days. Total length, 5.8; standard length, 5.2; length to vent, 4.1; length of head, 1.3; snout, 0.3; diameter of eye, 0.35; greatest depth before vent, 0.85 millimeters. Myomeres, 22 to vent plus 12 behind. The embryo shows a distinct reduction in the size of the yolk sac which has now become almost tubular due to its greater absorption anteriorly.

Pigmentation resembles that of the recently hatched larva except for an increase in density especially in the eye, and the appearance of heavy masses of yellow pigment spots (xanthophores) along the dorsal musculature and over the head. The mouth has opened and an opercular membrane is growing posteriorly over the gills. The air bladder is partially inflated. The gut is a simple tube dilated to some extent just behind the air bladder. The heart owing to the absorption of the yolk material now assumes an axis parallel with the median longitudinal

axis of the body, by the dorsal migration of the posterior end in an arc of approximately 30°.

6.8 millimeter stage (fig. 19). Age 7 to 8 days. Total length, 6.8; standard length, 6.1; length to vent, 4.7; length of head, 1.45; snout, 0.3; diameter of eye, 0.52; greatest depth before vent, 1.0 millimeters. Myomeres, 22 to vent plus 12 behind. The most conspicuous change, while the fish grows from 5.8 millimeters to 6.8 millimeters, takes place in the absorption of the yolk material, which is now represented by a few granules midway between the pectoral fin and the anus. The mouth has enlarged and the lower jaw moves rhythmically. The posterior end of the notochord has become bent upward slightly and rudiments of caudal fin rays are evident in the fin fold among the melanophores below the curved notochord. The outline of the fin itself however remains somewhat truncate. Fin rays are not evident elsewhere although a concentration of mesenchyme occurs at the region of the future dorsal. The operculum is well developed and a few gill filaments protrude beyond its posterior margin. Melanophores on the dorsal surface of the head are beginning to round up and others have appeared on the ventral margin of the operculum and on the dorsal surface of the air bladder. Dense yellow pigment is present all over the surface of the body. The lateral line has become more distinct. The alimentary canal is a straight tube enlarged anteriorly. The liver, reddish yellow in color, appears as a triangular mass on the ventral surface immediately posterior to the heart.

7.9 millimeter stage (fig. 20). Age 15 to 18 days. Total length, 7.9; standard length, 7.0; length to vent, 5.3; length of head, 1.65; snout, 0.35; diameter of eye, 0.71; greatest depth before vent, 1.20 millimeters. Myomeres, 22 to vent plus 12 behind. Melanophores about the head region have rounded up but over the rest of the body are stellate. A new row has appeared marking the lateral line. The yellow pigmentation is heavy and the general body surface is taking on an iridescent appearance. The caudal fin has forked into dorsal and ventral lobes supported by unbranched fin rays. The dorsal fin region is marked by an elevation of the fin fold and the appearance of elongated melanophores among the embryonic rays. The anal fin is indicated by an accumulation of mesenchyme and melanophores in the median fin fold which has become slightly lobed a short distance behind the anus. Embryonic fin rays have appeared in the pectorals. The otoliths have become almost as large as the lens of the eye. The operculum completely covers the gills. The air bladder is partially divided into two chambers. Minute spherical partially pigmented elevations are present on the lips.

9.4 millimeter stage (fig. 21). Age 22 to 23 days. Total length, 9.4; standard length, 8.3; length to vent, 6.4; length of head, 2.4; snout, 0.52; diameter of eye, 0.85; greatest depth before vent, 1.7 millimeters. Myomeres, 22 to vent plus 12 behind. The organism is becoming noticeably more opaque and has taken on a greenish yellow to fawn coloration. Aside from the margin of the operculum and adjacent to the fin rays, the melanophores are no longer stellate but contracted into spherical spots which are concentrated chiefly above the lateral line. The caudal fin shows little advancement over the 7.9 mm. stage, but the dorsal now

bears nine true rays. The median fin fold is beginning to disappear dorsally between the dorsal and caudal fins and between the caudal and anal fins ventrally. The anal and pectoral fins have developed distinct rays. The pelvic fins have appeared as minute lateral fleshy protuber-
·ances from the body wall midway between the pectorals and the anus.
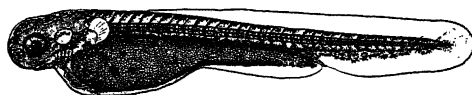
FIGURE 17

FIGURE 18
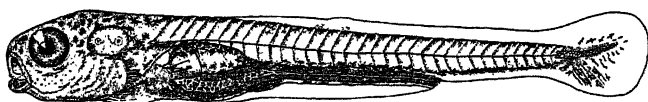
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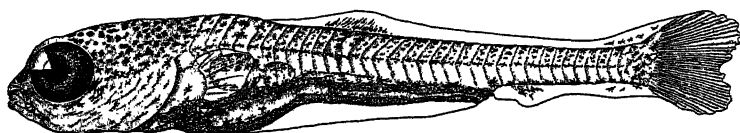
FIGURE 20
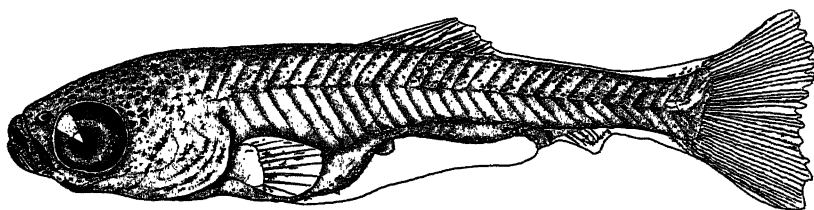
FIGURE 21

(Drawings by camera lucida)
Fig. 17.   Newly-hatched larva.   4.5 mm.
Fig. 18.   5.8 mm. stage.   1+ to 2+ days.
Fig. 19.   6.8 mm. stage.   7 to 8 days.
Fig. 20.   7.9 mm. stage.   15 to 18 days.
Fig. 21.   9.4 mm. stage.   22 to 23 days.

11.6 millimeter stage. Age 37 days. Total length, 11.6; standard length, 9.6; length to vent, 8.2; length of head, 3.1; snout, 0.68; diameter of eye, 0.95; greatest depth before vent, 2.3 millimeters. Myomeres,

22 to vent plus 12 behind. Differences from the preceding stage are principally in the greater development of the pelvic fins, in which there is an indication of rays. The preanal fin fold is reduced anteriorly, and the caudal rays are commencing to branch. The body has become more ' opaque, greenish yellow and iridescent in appearance.

15.7 millimeter stage. Approximate age 9 weeks. Total length, 15.7; standard length, 12.6; length to vent, 10.0; length of head, 4.0; snout, 0.8; diameter of eye, 1.4; greatest depth before vent, 4.5 millimeters. The fish now has acquired essentially the form and shape of the adult and varies from olive green or brown to orange red in color. Pigmentation is general. The body is fully scaled. Segmentation and branching of some of the fin rays may continue for some time (Grimm, 1937).

TABLE I

MEASUREMENTS OF GOLDFISH THROUGH PREHATCHING, LARVAL, AND YOUNG STAGES

Age	Total Length, mm.	Standard Length, mm.	Length to Vent, mm.	Length of Head, mm.	Snout, mm.	Diameter of Eye, mm.	Greatest Depth before Vent, mm.
Hours:							
45–50	2.5	2.4	2.0	0.70	0.10	0.25	1.00
60–65	4.4	4.2	2.9	0.78	0.17	0.30	0.95
76*	4.5	4.3	3.0	0.80	0.17	0.30	0.95
Days							
1½–2½	5.8	5.2	4.1	1.30	0.30	0.35	0.85
7–8	6.8	6.1	4.7	1.45	0.30	0.52	1.00
15–18	7.9	7.0	5.3	1.65	0.35	0.71	1.20
22–23	9.4	8.3	6.4	2.40	0.52	0.85	1.70
37	11.6	9.6	8.2	3.10	0.68	0.95	2.30
Weeks							
9	15.7	12.6	10.0	4.00	0.80	1.40	4.50
?	19.0	15.7	11.5	4.80	1.30	1.60	5.30
?	23.0	18.0	13.5	5.50	1.50	1.70	6.00
?	30.0	24.0	17.0	7.80	2.10	2.00	8.50

*Newly hatched larvae.

Table I gives the measurements of goldfish from 2.5 mm. (45 to 50 hours incubation) to a length of 30.0 mm. attained at the end of approximately 3½ to 4 months in an outdoor aquarium. All figures are average measurements of six specimens. The accompanying graph (graph 1) indicates the standard length, length to vent, length of head, greatest depth anterior to vent, snout, and diameter of eye, as percentages of the total length. The large initial drop of the greatest depth ratio is attributed to the absorption of the yolk substance. It will be observed

that for specimens from 15.7 mm. the percentage lines are almost parallel to one another, which would seem to indicate that only relatively minor if any changes in proportion are occurring.
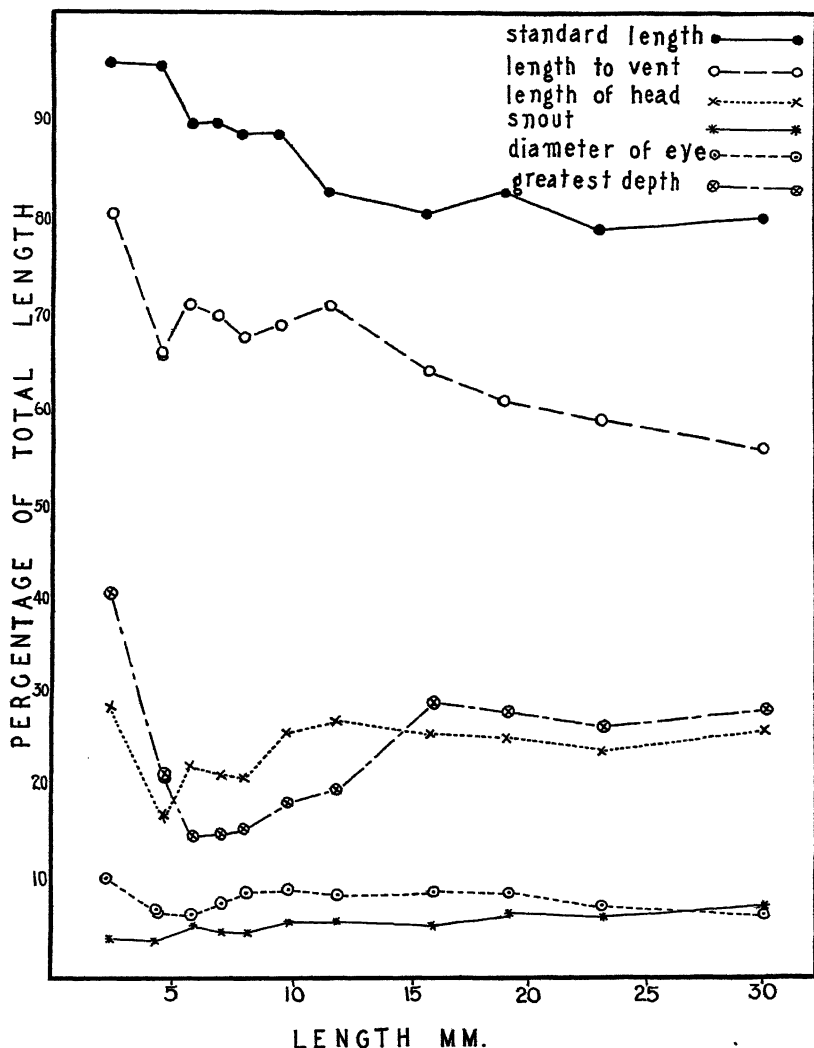
Graph 1. The relation between the total length of the prehatching, larval and young goldfish, and the standard length, length to vent, length of head, length of snout, diameter of eye, greatest depth before vent, expressed as percentages of the total length.

SUMMARY

This paper is the result of a preliminary study of the salient features of the embryology of the goldfish (*Carassius auratus* L.). It is based upon material obtained from Lake Erie and reared at the Stone Laboratory and at Port Stanley.

The goldfish is typical of the teleosts in its general development. The eggs which adhere to floating aquatic plants are 1.25 to 1.46 mm. in diameter and hatch in seventy-six hours at 25° C. The first cleavage takes place one-half hour after fertilization, and in nine hours the blastoderm has completely encircled the yolk with the exception of a small spherical blastopore. In twelve hours four somites are visible, in fifteen hours eight to ten. Two hours later the tail reached almost to the head, and eighteen somites have been differentiated. At twenty-four hours the somite count is twenty-five, the brain is distinctly divided into three primary lobes and the heart is beating rhythmically. Further development to hatching involves pigmentation by melanophores, enlargement of all the embryonic structures, and an elongation of the yolk sac posteriorly.

At hatching the larva is 4.5 millimeters in length, and restricted in movement by the weight of the yolk sac. By one and one-half to two and one-half days, a length of 5.8 millimeters is attained, and the yolk sac has been reduced to a narrow tubular band. Yellow pigmentation has appeared, and the standard myomere count of 22 to vent plus 12 behind is attained. The air bladder is partially inflated. At seven to eight days (6.8 millimeter stage), the yolk material has practically all disappeared. Rudiments of caudal fin rays are evident. The operculum practically covers the gills and the liver is present as a triangular mass at the anterior end of the body cavity.

The 7.9 millimeter stage (age 15 to 18 days) shows increased yellow pigmentation and reduction of melanophores to blackish spheres in the head region. The air bladder has divided into two chambers. By 22 to 23 days (9.4 millimeter stage) the organism is becoming more opaque. The pelvic fin buds have just appeared and fin rays are present in all the other fins. Pigmentation is concentrated above the lateral line.

At approximately nine weeks (15.7 millimeters) the fish has acquires scales, pigmentation is general, and the body bears essentially the adult characteristics.

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Animals in Winter

This field-book contains a large amount of general and specific information on where and how animals spent the cold months of the year. Such information is widely scattered in the literature and this book makes it accessible. Also the author includes many original observations. Although primarily intended as a guide for outdoor use, much fundamental ecology and many life histories are included. Indeed, the book is not the least bit superficial; zoologists as well as amateur naturalists can benefit by a careful reading of the text and examination of the numerous illustrations, which are good and often new. This book is a vivid example of true natural history; it is not a catalog of oddities. The animals are alive and the kind you will find, the events are real, and the subject matter is new. Who can miss examining this book, even though he proceeds to read it at the expense of prearranged tasks?—*Carl Venard.*

Field Book of Animals in Winter, by Ann H. Morgan, 528 pages; 283 drawings and photographs, including four plates in color by Roger T. Peterson. New York, G. P. Putnam's Sons. 1939. $3.50.

Edison

Edison's Open Door, written by Alfred O. Tate, his private secretary over a long period of years serves to give the reader an intimate glimpse into the activities of the Wizard of Menlo Park. The book is not a biography in the usual orthodox sense, but is rather a book of informal reminiscences from the great inventor's life. The book is entrancingly interesting from cover to cover, each page crowded with incidents and details in the development of many of the devices which have made our present day life what it is. An evening with this volume is an evening well spent.— *H. H. Nielsen.*

Edison's Open Door, by Alfred O. Tate, 320 pp. New York, E. P. Dutton & Co. 1938.

THE ALIMENTARY CANAL OF DIPLOTAXIS LIBERTA GERM. (SCARABAEIDAE: COLEOPTERA)

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This article is a morphological and histological study of the alimentary canal of the scarabaeid beetle *Diplotaxis liberta* Germ.

The beetle was collected at Westbury, Long Island, New York, while the author was working for the United States Entomological Sub-laboratory. The species is a night flier and about sixty specimens were collected from around street lights and fixed in Kahle's solution, then preserved in seventy-five per cent alcohol. Dr. E. A. Chapin, Taxonomic Investigator, Bureau of Entomology, United States Department of Agriculture, later identified it as *Diplotaxis liberta* Germ. The beetle is about twelve millimeters long and from reddish brown to black in color. According to Fall (7) it is restricted mainly to the Atlantic Coast States from Massachusetts to Georgia and is occasionally taken west of the Appalachian Mountains.

The author wishes to express his appreciation for the suggestions, criticisms and assistance so freely given by Dr. C. H. Kennedy, and for the helpful comments of many of his fellow students.

GROSS ANATOMY OF THE DIGESTIVE TRACT

General discussion.—The alimentary canal is divided into three main divisions as determined by the embryonic origin. The anterior portion (stomodaeum or fore-intestine) and the posterior portion (proctodaeum and hind-intestine) arise as ectodermal invaginations of the body wall. The epithelium of the mesenteron (ventriculus or mid-intestine) is formed by the proliferation of rings of cells in the endodermal tissue, eventually connecting the fore- and the hind-intestines.

Though there are some variations that occur, the different divisions and sub-divisions will usually be found to lie as follows: the fore-intestine (plate I, fig. 1) passes posteriorly along the median axis to the union of the prothorax and the mesothorax where it joins the mid-intestine. The mid-intestine continues posteriorly along the median axis for about one-third of its length; then it curves to the left and downward, then laterally across the abdominal cavity, making approximately two full spiral curves before looping anteriorly and then posteriorly inside of the second and smaller curve. The union of the mid-

intestine or stomach and the hind-intestine occurs at about the fourth abdominal segment.

The hind-intestine then passes caudally to about the fifth abdominal segment where it enlarges and curves dorsally, then to the right and slightly downward, tapering down to a smaller portion of the alimentary canal. It then curves dorsally and to the left passing over the last curve and a little to the left of the median axis, where it then curves to the right and posteriorly to the anus. The alimentary canal in toto is about thirty-nine and five-tenths millimeters long.

The Fore-Intestine

The fore-intestine is the shortest division of the alimentary canal. It comprises about one-ninth of the total length. The pharynx appears as a short dilated portion posterior to the mouth. The oesophagus connects the pharynx and crop and is a short narrow tube. (See plate I, fig. 1.)

The *crop* (CR) comprises the posterior two-thirds of the fore-intestine. The crop is dilated and is much larger than the oesophagus.

The *oesophageal valve* (OES. V) marks the division of the fore- and mid-intestine by a slight constriction. It is not visible externally.

The Mid-Intestine

The mid-intestine (M. I.) is the largest and longest division of the alimentary canal and comprises about five-ninths of its total length. There are no essential differences in the structures at the two ends, but there is a gradual tapering off in the size from the anterior to the posterior end. The anterior portion is about twice as large in cross-section as the posterior and the size varies with different individuals, depending upon the amount of food present in the canal. Both portions have numerous small crypts upon their outer surfaces.

The Hind-Intestine

The divisions of the hind-intestine are: anterior ileum; posterior ileum; colon; rectum and anus; to the anterior end are attached the malpighian tubules.

The *pyloric valve* (P. V.) forms the junction of the mid-intestine with the hind-intestine and is marked by a slight constriction. The pyloric valve, being internal, is not apparent externally.

The *malpighian tubules* (M. T.) are four in number and are attached separately to the canal, two anterior to the pyloric valve and two posterior to the valve. The two anterior ones are attached on each of the ventro-lateral sides whereas the posterior two empty close together into a bladder on the dorsal side of the anterior end of the ileum. The dorsal tubules are nearly twice as large in diameter as the other two. All are very long, and coiled around close to the canal and extend to the oesophageal valve where they turn posteriorly and terminate with their tips lying upon the mid-intestinal wall.

The *bladder* (BL.) attaches to the dorsal side of the anterior ileum just behind the pyloric valve.

The *anterior ileum* (A. IL.) begins at the division of the mid- and hind-intestine, is the shortest of the four divisions of the intestine, and

tapers off to be the narrowest section of the canal. The caudal or small end of the anterior ileum appears to be constricted at its junction with the posterior ileum but no valve was observed.

The *posterior ileum* (P. IL.) abruptly enlarges following its junction with the anterior ileum; then it tapers off gradually to the size of the colon. Through the thin layers of muscle tissue may be seen numerous folds in the epithelial layer of cells. See plate I, fig. 1, P. IL.

The *colon* (CO.) connects the posterior ileum with the rectum. It is a small uniform tube with well developed muscles on its outer walls. It merges gradually into the *rectum* (REC.) which gradually dilates for a distance, then contracts to the anus. The rectum lies in the region of the sixth, seventh and eighth abdominal segments. As on the colon, the circular and longitudinal muscles are well developed and visible externally.

HISTOLOGICAL STRUCTURE OF THE ALIMENTARY CANAL·

The Fore-Intestine.—In general the structure of the fore-intestine is the same throughout though there may be differences in detail.

The innermost layer is the intima, a chitinous layer which is homologous with the cuticula of the body wall. It is continuous throughout the fore-intestine and is a non-cellular homogenous structure. The intima is secreted by the hypodermal epithelial cells and forms a rather thick layer in the mouth (buccal cavity) and pharynx; then it gradually gets thinner as it passes caudally; upon reaching the oesophageal valve it thickens again. In the region of the pharynx it forms spines that protrude inward and caudally but they do not encircle the canal, being found on the folds in the lateral and dorsal sides of the canal. (See fig. 2, plate I.) The intima stains a deep green with Fast Green F. C. F. stain.

The epithelial layer (EPI.) of hypodermal cells just outside of the intima is composed of irregular flattened cells. Their cell walls are apparent but no basement membrane is visible. The cells are of the same character throughout the length of the fore-intestine.

Immediately outside of the epithelium are found the longitudinal muscles (L. M.) which vary in number from isolated strands to layers two or three strands in thickness. In the area of the pharynx and oesophagus they are most numerous and are distributed well around the canal as shown in a cross section. (See fig. 2, plate I.) They gradually become fewer in number towards the crop where only a few isolated strands occur.

The circular muscles (C. M.) lie outside of the longitudinal muscles. Here again, as with the longitudinal muscles, they are the thickest in the region of the oesophagus, being three to four strands thick, gradually diminishing in thickness caudad to one or two thin strands in the region of the crop and then thickening to two or three strands near the oesophageal valve. On the outermost part of the fore-intestine traces of a peritoneal membrane (P. M., fig. 6) composed of connective tissue can be observed here and there, though it is largely obscured by the fatty tissue that surrounds this region of the canal.

The oesophageal valve (fig. 5) which marks the inner division of the junction of the fore- and hind-intestine extends slightly down into the

lumen of the ventriculus as a fold. The valve is composed of an epithelium of hypodermal cells. The cells at the beginning of the fold are of a flattened, irregular type. They soon change to long columnar cells as they extend along the innermost side of the fold; then they gradually decrease in size on the reflexed side; and at the end of the reflexed layer they are cuboidal and join with the cells of the mid-intestine. The intima which continues around the valve disappears at the base of the reflexed layer of cells.

In this region there is a complete reversal of the position of the circular and longitudinal muscles. The circular muscles shift to become the inner layer of muscle fibers on the ventriculus. In the depression formed by the reflexed fold of the valve are numerous circular muscles (C. M.) which serve to close the valve. (fig. 5, plate I.)

Histology of the Mid-Intestine.—A histological study of the mid-intestine shows the following tissues to be much the same in size and structures throughout: (1) epithelium of endoderm cells supported by a basement membrane; (2) circular muscles; (3) longitudinal muscles; (4) "peritoneal" membrane of connective tissue. (fig. 6, plate I.)

The cells of the epithelium vary in shape and size during different periods of the feeding habits of the animal. They may be cuboidal after a period of secretion or they may be columnar during the period of resting, due to the accumulation of the digestive fluids within them. Shortly after feeding, the cells that are filled with the digestive fluid give off the fluid by the cell wall bursting, when the whole, or part, of the contents is expelled into the lumen of the intestine. This is termed the holocrine type of secretion. The burst cells in the holocrine type of secretion are replaced by other cells that are regenerated in the regeneration cell layer at their base or from crypts. These crypts (CRY., fig. 6) are nests of digestive cells which have sunken below both the epithelium and the circular muscles. Within the crypts are developed new cells that replace some of the cells that burst during secretion. The bases of the epithelial cells rest upon a basement membrane. The epithelial layer is generally folded to a greater or lesser degree throughout the length of the canal. Fig. 12 shows the abundance of the crypts as indicated by the distribution of their openings into the stomach.

Immediately outside of the basement membrane lie the circular muscles (C. M., fig. 6) in a layer one strand thick which completely encircle the canal by the interlacing of their ends, when viewed in a cross-section. Still further outward is a single layer of numerous isolated strands of longitudinal muscles. These appear to be connected in places by a thin connective tissue which is probably the peritoneal membrane. The relative position of the longitudinal and circular muscles about the mid-intestine is the reverse of that in the fore- and hind-intestine.

Surrounding the food within the mid-intestine is a very thin structureless peritrophic membrane (PER. M.). It is thought to be secreted by cells at the base of the reflexed layer of cells of the cardiac or oesophageal valve. Its function may be to protect the delicate inner ends of the epithelial cells from the coarse foods.

Histology of the Hind-Intestine.—The origin of the hind-intestine is similar to that of the fore-intestine, being formed from the invagination

of the body wall. The pyloric valve (fig. 7) and the two forward malpighian tubules mark the union of the anterior and with the ventriculus.

A microscopic study of the canal shows the following layers present: (1) an intima; (2) an epithelium of hypodermal cells resting on a basement membrane; (3) longitudinal muscles; (4) circular muscles; (5) "peritoneal" membrane of connective tissue. (figs. 9 and 10, plate II.)

The malpighian tubules (M. T.) are of ectodermal origin, although the two anterior ones appear to open into the ventriculus. They are made up of large irregular cells with oval or spherical nuclei. (figs. 3 and 4, plate I). The number of cells vary from four or five to thirteen or fourteen in a cross-section. The larger sections near the proximal end contain the greater number of cells. The cells secrete fluids by the merocrine type of secretion. Surrounding the mouth of the tubes and extending up in them a short way is a delicate layer of intima, whereas the rest of the inner surface is lined with a striated border. In some sections a striation also appears near the basal side of the cell. The outer surface of the tube is covered with a thin layer of connective tissue.

The pyloric valve (fig. 7) marks the greater part of the internal junction of the mid- and hind-intestine, and consists of a definite folding of the epithelial hypodermal layer into the lumen of the anterior ileum. The cells become extremely elongated and extend out as irregular fan-shaped structures in longitudinal section. The valve consists of two distinct forms of fan-like structure, the central and lateral structure being somewhat flattened and extending downward into the lumen, while the dorsal structure is semicircular with one edge extending into the lumen and the other into the bladder. (fig. 7, plate II.)

The inner surface of the valve is lined with a thin layer of intima, which begins with the cuboidal cells on the anterior side of the valve and extends throughout the ileum in numerous folds. External to the valve and within its folds are a number of circular muscles (C. M., fig. 7) whose function is probably that of closing the valve. A few longitudinal muscles are scattered here and there among them. As at the junction of the fore- and mid-intestine, the muscles here again are reversed in their relative positions.

The bladder (fig. 7) is probably an evagination of the dorsal surface of the ileum, adjacent and caudal to the pyloric valve. The layer of intima lines the inner wall of the bladder. The cells of the epithelium are very irregular, flattened and small. On the outer surface are scattered thin strands of longitudinal and circular muscles. (fig. 7, plate II.)

In the remainder of the ileum (P. IL., fig. 1; and figs. 8 and 11) the layer of epithelium is greatly folded and composed of small irregular shaped cells. Immediately outside of the cell layer are a few isolated strands of longitudinal muscles; outside of these are the circular muscles which vary in thickness from one to two strands in the anterior region and to three or four strands in the posterior region. Outside of the circular muscles are isolated strands of a second layer of longitudinal muscles and a thin layer of peritoneal connective tissue.

The posterior ileum (P. IL., fig. 1) which lies between the anterior ileum and the colon is probably the most outstanding of all the divisions of the canal. The epithelial layer of very irregular cells lies in deep

crosswise folds that are broken by short lengthwise folds; these folds extend into the lumen of the canal, leaving only a small passage for the food throughout the ileum. (See figs. 8 and 11.) These small separate folds are termed by some workers "papillate processes." Surrounding each of them is a thick non-cellular mass of substance that stains a deep green, with Fast Green F. C. F. stain. (fig. 8, plate II, posterior ileum.)

Spines were observed upon the intima at the anterior end of the ileum. The irregularity of the cells probably aids in holding the mass in place. Particles of food sometimes appear between the folds. (fig. 11, plate II, posterior ileum.) Immediately outside of the epithelium is a poorly developed layer of circular muscles. These may be seen at the end of the folds in a cross-section. (fig. 11, plate II, anterior ileum.)

The longitudinal muscles form the outer layer of muscles and are well developed but very thin.

The intima at the anterior end of the ileum is thickened and contains a few spines, while that lining the inner surface of the folds is very delicate and is free of spines.

The ileum gradually merges into the colon. In the colon the intima is of moderate thickness. The circular muscles are the inner layer of muscles. They are well developed and are one to two strands thick. The longitudinal muscle layer is poorly developed and. lies as isolated strands and small groups of several strands outside of the circular muscles.

The colon and rectum are very much alike in structure and no difference other than that of size appears. The intima and epithelium are continuous throughout. The epithelium of hypodermal cells that extends throughout the rectum (figs. 9 and 10) is divided into six main longitudinal and several subordinate folds. The outer ends of each of the six main folds are attached to the circular muscles by muscle fiber. The nuclei here, as everywhere else in the canal, are clear and relatively large.

The circular muscles which are in a single layer in the colon gradually become more numerous after they merge with the rectum, until near its center they form a layer four to five strands thick (fig. 10). This then gradually thins down to a layer one strand thick and just anterior to the anus thickens again into a layer nine or ten strands thick. The outer longitudinal muscles are isolated strands. Strands of "peritoneal" membrane of connective tissue appear here and there, all along the outer surface of the hind-intestine. (figs. 9 and 10, plate II.)

SUMMARY

The alimentary canal of *Diplotaxis liberta* Germ. is morphologically divided into three main divisions, namely: fore-intestine, mid-intestine, and hind-intestine. These main divisions are further divided into: Fore-intestine; Pharynx, oesophageal valve. Mid-intestine: entirely stomach. Hind-intestine: Phloric valve, malpighian tubules, bladder, anterior and posterior ileum, colon, and rectum.

The following layers are present: Fore-intestine: Intima, epithelium of hypodermal cells resting on a basement membrane, longitudinal muscles, circular muscles, and "peritoneal" membrane of connective tissue.   Mid-intestine: Peritrophic membrane, epithelium of endoderm cells and regenerative cells resting on a basement membrane, circular muscles, longitudinal muscles and "peritoneal" membrane.   Hind-intestine: Intima, epithelium of hypodermal cells resting on a basement membrane, inner longitudinal muscles (in anterior end), circular muscles, outer longitudinal muscles and "peritoneal" membrane.

The malpighian tubules are four in number and enter separately into the canal, two anterior to the pyloric valve and two posterior to the valve.   The anterior tubules are attached to the ventro-lateral sides and empty directly into the canal; whereas the posterior ones empty into a bladder on the dorsal side which has a common opening into the canal.   The bladder is an invagination of the epithelium of the ileum.

The papillate processes of the posterior ileum are folds of the epithelium that project down into the lumen.   These folds are covered with a non-cellular mass of material.

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EXPLANATION OF PLATES

PLATE I

Fig. 1. Dorsal view showing gross dissection of the alimentary canal of *Diplotaxis liberta* Germ.

Fig. 2. Cross-section through the oesophagus.

Fig. 3. Cross-section through malpighian tubule near the distal end.

Fig. 4. Cross-section through malpighian tubule near the proximal end.

Fig. 5. Longitudinal section through the oesophageal valve.

Fig. 6. Cross-section through the mid-intestine.

PLATE II

Fig. 7. Longitudinal section through the pyloric valve, showing bladder and entrance of malpighian tubule.

Fig. 8. Cross-section through the posterior ileum.

Fig. 9. Cross-section through the rectum near the anterior end, showing the relationship of the muscles.

Fig. 10. Cross-section through the rectum near the middle.

Fig. 11. Portion of a cross-section of the posterior ileum enlarged, showing the papillate processes.

Fig. 12. Diagram of a portion of the external wall of the mid-intestine greatly enlarged, showing the number of crypts per unit area.

KEY TO ABBREVIATIONS

A. IL.....Anterior Ileum
BL.......Bladder
B. M.....Basement Membrane
C. M.....Circular Muscles
CO.......Colon
CR.......Crop
CRY.....Crypt
EPI......Epithelium
FD.......Food
F. T.....Fat tissue
INT......Intima
L. M.....Longitudinal Muscle
LU.......Lumen
M. I......Mid-intestine

M. T......Malpighian tubule
OES......Oesophagus
OES. V...Oesophageal Valve
PA. PR...Papillate process
PER. M...Peritrophic membrane
HP.......Pharynx
P. IL.....Posterior ileum
P. M.....Peritoneal membrane
P. V.....Pyloric Valve
REC......Rectum
REG. C...Regenerative cell
S. B.....Striated Border
SP.......Spines

FIG. 1

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6

EPI

S B

M.T.

STOMACH

L.M

CM

EPI

INT

LU

FIG 9

P.V.

L.M

BLADDER

C M

PM

L.M

CM

ILLEUM

LU

INT.

EPI.

FiG 10

INT.

FIG 7.

PA PR

FD

EPI

PA PR

EPI.

LM

CM

FiG II.

FT.

FIG. 8.

FIG.12.

CRY
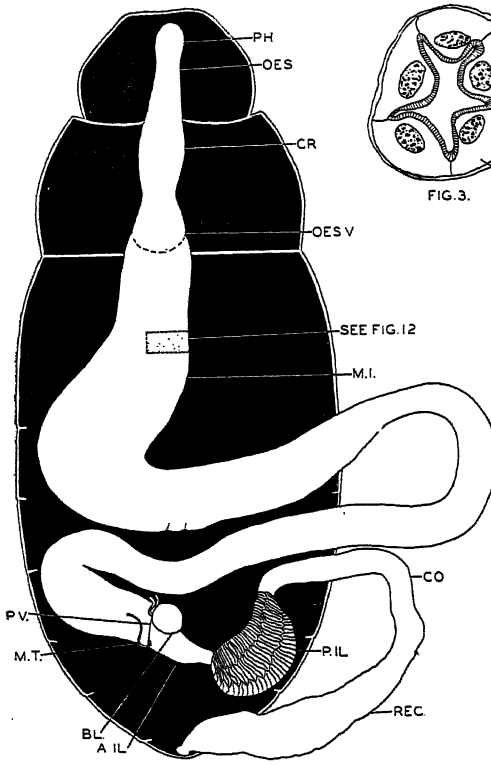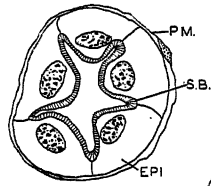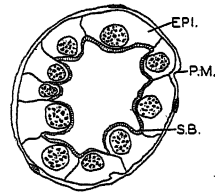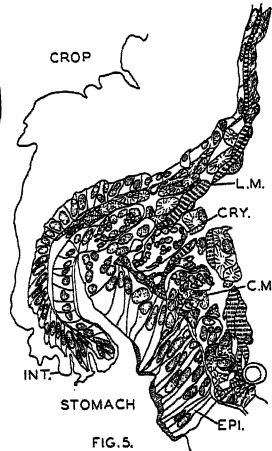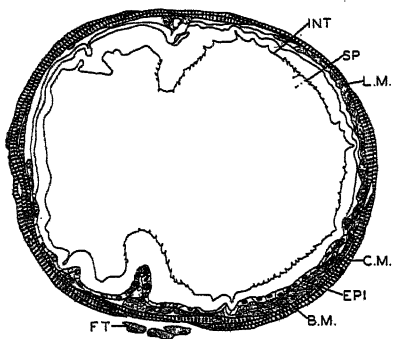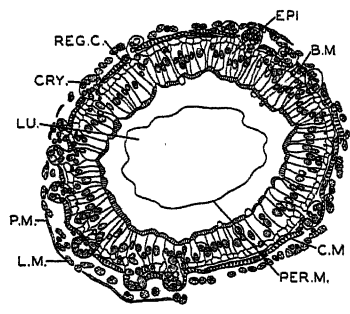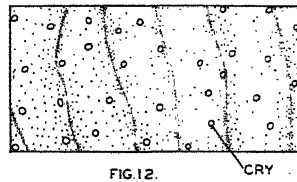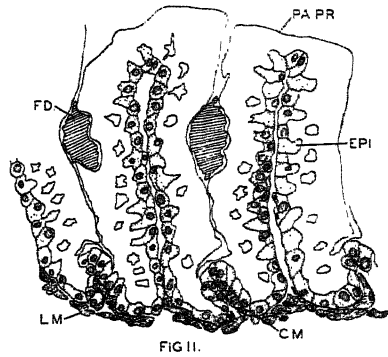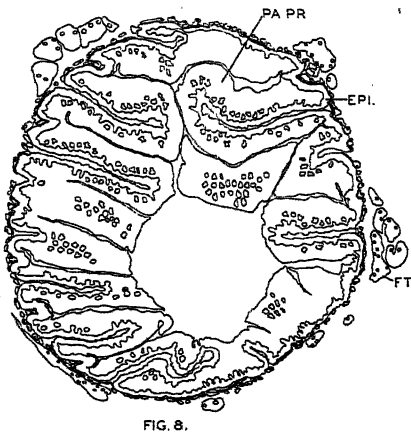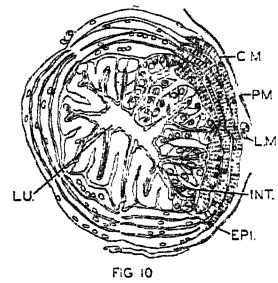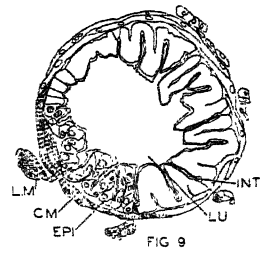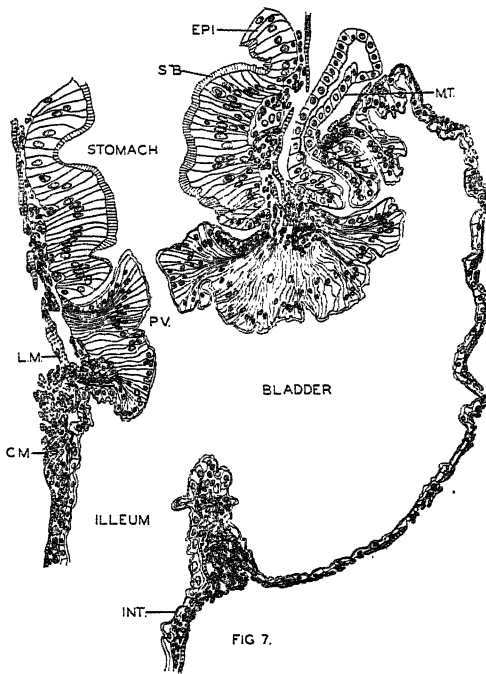
BOOK NOTICES

A Revision of a Standard Text in Astronomy

Since 1927 when the second volume of "Astronomy" by Russell, Dugan and Stewart was written, this work has been the standard text and reference work on astrophysics and stellar astronomy. Since that time many new developments have occurred, particularly in astrophysics. It is interesting and rather astonishing to note that these new developments require in the main that the volume need be expanded rather than revised. This may be interpreted in either of two ways:

Either the authors have not found it expedient to revise the volume in its entirety or their original choice of material was so well made that only additions were necessary to bring the volume up to date. The reviewer has examined the book carefully and finds that a combination of the two interpretations is probably the correct one. A complete revision would have involved an amount of labor that would not have been justified by the additional gain in coherence over what has been achieved by the simple addition of new material. This must be construed as a tribute to the original judgment of the authors.

The new volume as it now stands is subject to the same criticisms that could be made of the old volume. The greatest of these concerns the pictorical material on which so much expense was saved by the printers that it is of little value in many cases. Typical of this is the poor quality of the reproductions of the many spectrograms most of which are so poor that they are of little help to the reader.—*C. E. Hesthal.*

Astronomy Vol. II, Astrophysics and Stellar Astronomy, by Russell, Dugan and Stewart. xii+488+xxx (appendix) pp. Boston, Ginn and Co. 1939.

Plane Sets of Points

This is an excellent little book in more ways than one. Topology is one of the most important fields in modern mathematics, and some of the most outstanding achievements of the mathematical research work of this century belong to the field of Topology. The book under review serves, in the first place, the important purpose of providing a picture of modern Topology in a manner that should appeal to the non-specialist. By restricting the discussion to the study of the plane, technical difficulties are almost entirely eliminated and the author can concentrate upon the methods and ideas underlying the theory. The discussion is strictly scientific, but extremely clear and careful, and should be within the reach of anybody who took some graduate work in mathematics. Still, there is very little in the book that is trivial. In fact, most of it represents the best thought of modern mathematics, both in results and in methods. The book also serves, in the second place, the equally important purpose of providing a textbook for those professional mathematicians who do not specialize in Topology, but have to use topological results and methods in their work, either in teaching or in research. The theory of functions of a complex variable is the field which the author of the book had primarily in mind in selecting his material, but the reviewer, judging by his own experience, feels that the book should be extremely valuable for all those who are engaged in research involving double integrals. The typography of the book is excellent.—*Tibor Rado.*

Elements of the Topology of Plane Sets of Points, by N. H. A. Newman. viii+221 pp. Cambridge, at the University Press; New York, the Macmillan Co. 1939. $3.50.

Parasites

The author has written a lively and whimsical account of the protozoa and of his journeys while studying them. When prose fails he turns to poetry, some of which is quite clever. The illustrations are of two kinds: some are standard drawings, diagrams, or photographs, others appear to have been done under the influence of James Thurber. Of these latter, some are excellent, others rather pointless.

Although it is difficult to predict just how much actual parasitology the average reader will learn from this book he will certainly find it both interesting and entertaining.—*J. M. Birkeland.*

Big Fleas Have Little Fleas, or, Who's Who Among the Protozoa, by Robert Hegner. 285 pp. Baltimore, The Williams & Wilkins Co. 1939. $3.00.

Social Life of Animals

This subject is ably and very interestingly discussed by one of the leading authorities in the field of animal social life and animal behavior. For some thirty years Dr. Allee has experimented in this field. After an interesting introductory discussion of the history and the development of natural history and many observations made by early workers the author traces the development of co-operation among animal types and the effects of overcrowding. From this is developed the idea of animal aggregations and the effect of mixed populations, the behavior of groups of animals and their effects upon each other especially as regards such phenomena as the rate of learning. The author discusses group organization among animals in general and draws some human implications illustrated by international attitudes and animal reactions of human beings. Finally social transitions are discussed and the author attempts to answer the question, "When does an animal become truly social?" The entire treatise is interesting reading and illustrations are drawn largely from experiments of the author, his students and co-workers.—*D. M. DeLong.*

The Social Life of Animals, by W. C. Allee. 293 pp. New York, W. W. Norton & Company Inc. 1938. $3.00.

The World of Insects

This volume is written in popular style, is practically non-technical in use of terminology, and covers the "world of insects" in an effective manner for the layman. Because of its popular nature it should be an excellent text or supplementary reading for high school biology courses.

The contents by chapters are as follows: Introduction, Insect Structures, How Insects Grow Up, the Growing Up of a Swallow-tail Butterfly, Insect Foods and Feeding Habits, Insect Food-Getting Devices, How Insects Reproduce, How Insects Get Air, How Insects Move, How Insects Are Protected, Insect Voices, Insect Fitness, Insect Orders, Social Life Among the Insects, The Value of Insects, Injurious Insects and Their Control, Where to Look for Insects, Rearing Insects, How to Collect and Preserve Insects.

One of the outstanding features of the book is the excellence of the many photographs and drawings. The striking black and white pen and ink drawings and the greatly enlarged photographs, the great majority of which are original, catch the eye of the reader readily.

A selected list of references is given at the end of the book, arranged according to the fields to which they apply.

This fascinating book is printed and bound in the usual high quality of McGraw-Hill Books.—*R. H. D.*

The World of Insects, by Carl D. Duncan and Gayle Pickwell. 409 pp. 194 Figures. New York, the McGraw Hill Book Company. 1939. $3.50.

Cosmic Rays

This small book, written in a very lucid style, is based upon the revision of three semi-popular lectures delivered at the University of Virginia and Trinity College. Lecture I treats with the discovery and general significance of cosmic rays. The early works of Kolhörster are pointed out. Millikan's answer to the question, "What are cosmic rays good for?" expresses a very worthy point of view. Lecture II treats with the superpower particles which make up the penetrating cosmic rays. Many cloud chamber pictures show the existence of positrons and particle showers. A very excellent section on the evidences for the new mesotron particle, about 150 times as heavy as the electron, is given toward the later part of this lecture. Lecture III treats with the relationship of the earth's magnetic field to the cosmic ray energies and their terrestrial distribution. The latitude effect in cosmic rays is

summarized in print and in graphs. The book closes with speculations as to the place and mode of the origin of the cosmic rays. Forty-two figures help to make this a very readable book. It is highly recommended to any one who wishes the large field of cosmic rays boiled down to a very digestible form within a reading time of a few hours.—*M. L. Pool.*

Cosmic Rays, by R. A. Millikan, 134 pp. New York, The Macmillan Co. 1939. $2.50.

Science and Society

In a period when the social importance of all our institutions is being challenged, it is not surprising to find that science has been minutely examined. This volume is an analysis of what science does for the people of the world and a prediction of what it could do if reorganized according to one author's plans. The historical aspects are authoritatively dealt with. Science has always been an outgrowth of necessity: it is not a luxury. Pure science, which is what the layman so often thinks of, originated in the early part of the 19th century. Although science has developed because of the practical aspects, its financing has been extremely indefinite.

Scientific organizations from the first one, Accademia de Lincei, founded in Rome (1601) to the American Association of Scientific Workers are considered in detail. The scientist and particularly his welfare, and attempts to better highly unsatisfactory conditions in employment through organization, are thoroughly discussed. One sees the contributions, past and present, of different nations contrasted and the development and utilization of science in these nations influenced by political ideologies.

The faults of industrial, governmental, and scholastic institutions, all of which support and direct research, are abundantly presented and a plan of reorganization is offered. This section has been read with very great care and this reviewer is bewildered over the fact that the features in administration, so severely condemned in old systems, remain in the scheme of reorganization. Although the section on administrative difficulties appears abortive, there are many splendid contributions on other topics. Some major problems considered are future expansion, the training of scientists which involves reorganization of existing curricula, employment at adequate salaries, the future nature of the different sciences, scientific communication, and the finance of science. Communication, for instance, is essential and involves travel, numerous languages, over 33,000 periodicals, and thousands of monographs each year. This phase of the scientists' life lacks organization at present.

This book contains sections that are debatable and much bias of opinion is evident. A tremendous amount of data is offered and the social involvements are admirably presented. The author has written for the inquiring minds of all scientists, and people in other fields of activity interested in science. The content of this book demand attention as the issues involved are real ones.—*Carl E. Venard.*

The Social Function of Science, by J. D. Bernal. 482 pp. New York, the Macmillan Co. 1939. $3.50.

Physiological and Pathological Chemistry

In preparing a text book of chemistry for nurses, the author has kept in mind the fact that while some schools of nursing offer a so-called long course in chemistry consisting of ninety clock hours, there are many other schools in which only thirty to forty hours are allotted to the teaching of chemistry. He has therefore attempted to eliminate all unimportant and unessential details in order to make the material actually presented as clearly as possible to the student nurse. However, the graduate nurse who frequently has to serve as instructor in chemistry as well as in other subjects will also find the book useful, as well arranged lists of study questions have been included at the end of each chapter.

The book is divided in three parts. Part I, designated as an introduction to chemical science, discusses selected topics in a clear and readable style which the student nurse ought to be able to follow without too much difficulty. Weighing and measuring, chemical substances, elements, compounds, atoms, molecules, symbols, formulas, chemical equation, valence, oxygen, energy transformations, water, types of solutions, and some of their properties, emulsions, osmosis, colloidal

systems, acids, bases, salts, ionization, pH notation, buffers, oxidation-reduction reactions and finally a chapter of introductory organic chemistry are among the subjects included in Part I. pH notation is the only topic presented in such a way that additional aid beyond the text book is required. Since the author has presented most of his material in such a clear fashion, it seems regrettable that a few pages devoted to the chemistry of hydrogen, the halogens, nitrogen and ammonia, and carbon and carbon dioxide could not have been included.

Part II, entitled Physiological and Pathological Chemistry, deals with the nature of enzymes, the chemistry and metabolism of lipids, carbohydrates, proteins, digestion, inorganic metabolism, the urine, hormones, vitamins and an introduction to nutrition and dietetics, including the types of diets prescribed in certain illnesses. The order or presentation of some of the topics is the only reason for unfavorable criticism of this section of the book. Since food must be digested and absorbed before the reactions described in the chapters devoted to metabolism can take place, it would seem a more logical arrangement to discuss digestion and absorption before metabolism. Furthermore, since the author has recommended the use of only part of his text book for short courses in chemistry for nurses, the reviewer believes that a student nurse could make more practical use of her information if she were to study digestion and absorption than if she had a hazy idea about intermediate metabolism. (Digestion follows immediately after the chapters recommended for a short course).

Part III consists of a series of laboratory exercises covering the material discussed in Parts I and II, while the appendix contains useful directions for removing stains from clothing and bedding.

Although there are numerous points throughout the text to which one may take exception, the reviewer feels that the book makes a distinct contribution to the teaching of nurses and is a decided advance over other chemistry texts written especially for nurses.— *Helen L. Wikoff*

An Introduction to Physiological and Pathological Chemistry, by L. Earle Arnow, 555 pp., St. Louis, The Mosby Co. 1939. $3.50.

Ecology and Society

The author of "Deserts on the March" and "This is Our World" has prepared in this remarkable little book a concise yet broad overview of the interrelations of living things. The work of the botanist, zoologist and ecologist is often specialized, and its broader implications are seldom recognized by society; often, in fact, are not recognized by the workers themselves. Now and then a biologist not only glimpses the vast horizons of ecology, but is capable of translating the deeper and all-pervading theme into the practical language of commerce, business, health, and community existence. Such a man is Paul Sears, and we tender him deserved praise for setting forth so clearly the social functions of ecology.—*L. H. S.*

Life and Environment, by Paul B. Sears. xi + 175 pp. New York, Bureau of Teachers College, Columbia University. 1939. $1.85.

All About the Blood Groups

Wiener's revised edition should prove to be a most valuable source book for those workers in the various fields in which the blood groups play major roles.

Certain out-of-date items and superfluous explanations have been deleted while all the very latest principles and technics pertaining to the use of the blood groups have been added. Practically every chapter has undergone revision and this revision has been done in terms of deleted or added materials; that is, rewritten in such a way that the reader is not bothered by a "patch-quilt" sort of affair.

Dr. Wiener thoroughly discusses the sub-groups of A and AB as to sensitivity, reactivity, heredity and distribution. The chapters on the M and N groups are enlarged and brought up-to-date while the chemistry of all the substances is discussed more fully than in the previous edition. The anthropology of the varied groups is given in more detail and includes the most recent facts pertaining to their distribution.

The chapter on selection of donors and survival of transfused blood cells has been enlarged to include a chart of correct procedure for cross-matching bloods, a discussion of "blood banks," physical examination of blood donors, and professional

and volunteer donors. The best and latest technics for transfusing blood are given and space is devoted to discussing the advantages and disadvantages of transfusing preserved blood.

Two chapters have been made out of the original one on indications for and reactions to blood transfusions. The first deals with indications for and results of transfusions; the second with reactions to transfusions. The chapter on the medico-legal applications of the groups has also been made into two. One deals with the applications of the groups in cases of disputed paternity, the other with individual identifications of stains.

These are but a few of the many changes which help to round out an altogether satisfactory and necessary book.—*H. S. Hyman*.

Blood Groups and Blood Transfusion, by Alexander S. Wiener. Second edition., 306 pp., Springfield, Charles C. Thomas. 1939. $5.00.

Principles of Forest Entomology

Following the same style of presentation as used in the first edition, Professor Graham has enlarged and rewritten many parts of his well known text in forest entomology in the recently published second edition.

Some of the additions include discussions of pests not mentioned in the previous edition, namely, the Pandora moth, European Spruce Sawfly, European Pine Shoot Moth, Melanophila beetles, and a number of other Lepidopterous leaf-eaters. The sections dealing with barkbeetles and termites have also been greatly enlarged. A new chapter dealing with other relations of forest insects appears at the end of the book. It includes discussions of insects as transporters of insects; the relation of insects to wood rot and stains, parasitic fungi, and virus diseases; followed by a glimpse into the future. The questions on literature are omitted in the revision.

The chapters on biotic balance, environmental resistance, biotic potential and insect abundance have been expanded to include information from investigations of the past ten years. They cover the underlying principles which should be considered for the control of any insect problem, but are so very important to the forest entomologist or forester because of the inapplicability of most chemical control measures to forested areas.

A few more illustrations have been added, the first edition having 149 and the second 165.

In the revised form the book should continue to serve as a standard text on the subject for years to come.—*R. H. Davidson*.

Principles of Forest Entomology, by S. A. Graham. Second edition, 410 pp. New York, the McGraw-Hill Book Co. 1939. $4.00.

Racial Origins

At a time when the scientific knowledge of human racial types, especially in Europe, is bandied about and perverted for various extraneous ends it is fitting that a book of this scope and dispassionate impartiality should be published. Coon has provided us with a highly condensed, efficiently organized compendium of the extant knowledge concerning the physical form of man in Europe and the adjacent portions of Asia and Africa from the time of *Homo sapiens'* first appearance in the late Pleistocene to the year 1938. The complex story of the origin, evolution, mixture and migration of European physical types has been correlated wherever possible with culture, linguistics, political divisions of the various periods and of course with geography and chronology. Over 4000 sources in at least 21 different languages have been abstracted for the anthropometric data alone. The basic thesis of the book is that the living white types of Europe owe their original differentiation to a dual origin, namely, (1) a *Neaderthaloid-sapiens* hybrid type which the author believes inhabited Europe during the later part of the Ice Age, and (2) a purely *sapiens* Mediterranean stock with several varieties which began colonizing Europe from the south and east about 3000 B. C. Ten racial types and nine subtypes are recognized in the present white population of Europe. The reader who is familiar with the earlier work of the same name published about 40 years ago by W. Z. Ripley, to whom the present work is dedicated, will find the former work superceded in almost all respects, so great has been the accumulation of anthropological data in

the interval. The physical anthropologist, however, is still forced to deal almost exclusively with phenotypes and Coon's conclusions regarding origins, while for the most part eminently sound in the light of present knowledge, must await more extensive data on human genetics before they will be finally vindicated or rejected. —*John Gillin.*

The Races of Europe, by Carleton S. Coon. xvi+739 pp. New York, the Macmillan Co. 1939. $7.00.

The Romance of Silver Mining

Of particular interest in these days of governmental expropriation is this account of the fortunes of the Shepherd family in the Chihuahua silver mines. Mistakenly given to me for review as a physicist because of its title, "The Silver Magnet," I nevertheless spent several interesting hours with this book. In 1880, the Shepherd family (nine of them!) and a group of specialists and servants, seventeen in all, left the comforts of Washington where the senior Shepherd (the father of the author) was a Governor of the District of Columbia (a new office to this reviewer) and started on the long and tedious journey to Batopilas, Chihuahua. Here they took over a mine in a two hundred fifty year old mining locality and tried to run it with American efficiency. Details of the process of getting the silver to railhead six hundred miles away, and of the government of Mexico before and during the time of Porfirio Diaz take up several chapters. An account follows of the education of the author back in the United States and of his adventure on the way back to Batopilas. Then work, which seems to be glossed over lightly, while vacation journeyings all over Mexico occupy a great deal of space. The history ends with a defense of Diaz and a diatribe against the "great liberator," Villa.—*J. B. Green.*

The Silver Magnet, by Grant Shepherd, 302 pp. New York, E. P. Dutton and Co. 1939. $3.00.

Conservation

This volume by four members of the Cornell faculty aims to present for the average citizen the basic facts and principles governing the use of our natural resources. The authors are authorities in the areas covered, and the presentation is ably accomplished with readable text and excellent illustrations. The broad viewpoint of national welfare requires breadth of view of the fields treated, but more emphasis could have been placed upon wise use, and avoidance of waste, and less upon simply conserving. The authors' thesis is that the ruthless exploitation of our natural resources can be stopped only by intensive and extensive co-operation between the Federal and State governments, great and little corporations, and individual citizens. More emphasis should have been placed upon methods of effecting such co-operation, and less upon centralizing responsibility and authority in Federal and international agencies.

The expressed aim of this book is to foster conservation consciousness in the individual citizen by giving him an understanding of the problems. This book makes plain the complexity of the job, and the average citizen who reads it will probably decide that the job can only be handled by people who make it their vocation. All books of the kind will doubtless help the cause of conservation, but nothing short of a vigorous emotional appeal, presented to a bigger audience could hope to incite the co-operative action called for, and then only if accompanied by directions for specific actions by every individual.—*T. H. Langlois.*

Conservation in the United States, by A. F. Gustafson, H. Reis, C. H. Guise, and W. J. Hamilton, Jr. xi + 445 pp. Ithaca, Comstock Publishing Co. 1939. $3.00.

Bibliography of Drosophila Genetics

Drosophila stands at the pinnacle of experimental material for the study of genetics. The fourteen years from 1910 to 1924 resulted in 381 titles, listed in "The Genetics of Drosophila." The fourteen years from 1925 to 1938 provided seven times as many articles, namely, 2,584, making a total of 2,965 titles listed in the excellent bibliography now under review. The arrangement is alphabetical by authors, no attempt being made to classify the subjects. The bibliography is

practically complete on the genetic side, and reasonably so in matters of morphology, physiology and systematics. It should be invaluable to geneticists; and the Imperial Bureau of Animal Breeding and Genetics is to be commended for undertaking its publication.—*L. H. S.*

Bibliography on the Genetics of Drosophila, by H. J. Muller, 132 pp., paper bound. Edinburgh, Oliver and Boyd. 5s.

North American Snakes

Dr. Raymond L. Ditmars, already the author of a number of noteworthy books on reptiles, again brings together in this volume herpetological material otherwise available only in widely scattered technical papers, and presents it in non-technical terms useful to both the specialist and layman. Beginning with a general discussion of the distribution, ecology and behavior of various types of snakes of the North American continent, he deals with the snakes of northeastern, southeastern and western North America in three separate parts of the text. For each area, each recognized species and sub-species is listed in a simplified key and subsequently described in considerable detail with regard to size, form and scalation, color, distribution, and habits. Poisonous species of each region are discussed separately from the non-poisonous species. Part V includes a useful chapter on the treatment of snake bites in both man and domestic animals, together with an excellent discussion of the preparation and action both of venom and of anti-venom serum. This is followed by a complete classified list of North American Snakes, comprising 6 families, 48 genera, 140 species, and 138 subspecies, a list of general references, and index, and a series of 48 excellent photographic plates, designed to show diagnostic features.

To the reader already familiar with the snakes of his own locality, the over-all view of the snakes of the entire continent north of Mexico provided in this book should prove an attractive feature. The Ohio naturalist traveling outside the state should find this a useful adjunct to his field equipment.—*John W. Price.*

A Field Book of North American Snakes, by R. L. Ditmars. xii+305 pp., 48 plates. New York, Doubleday, Doran & Co., Inc. 1939. $3.50.

Saving Our Soils

Soil Conservation is a semi-technical, semi-popular discussion of soil erosion, by the Chief of the Soil Conservation Service, with the aid of various individuals within his organization. Essentially, it is an encyclopedia of the activities of the Soil Conservation Service. The book contains 993 pages, including 358 excellent photographs, 61 graphs, 17 maps and 47 tables of data.

The author develops a vivid concept of the seriousness of erosion and the reader is never left in doubt as to the author's opinions regarding the menace of erosion to agricultural soils. He cleverly presents a survey of the erosion problem of the United States upon a regional basis. He calls attention to the various factors that are responsible for soil erosion. Finally, he suggests methods for controlling erosion and explains the results that the Soil Conservation Service has achieved in the different agricultural areas of the nation.

The author leaves the impression that soil erosion is the only factor that is responsible for soil deterioration. Therefore, the book is definitely concerned with soil erosion and does not stress the broader aspects of soil conservation. It is also implied that the conservation of soils is primarily a federal responsibility in co-operation with the individual farmer and does not emphasize the contributions that the various state experiment stations have made and will continue to make to the problem of soil conservation.

This book should be in the library of every individual who is interested in any phase of conservation. It contains a wealth of material that cannot be obtained from any other source. Teachers of science should have access to the book for reference to their students, since many of the chapters fit into the subject matter of most general science courses. Soils men and agronomists will find it to be a handy encyclopedia of the various aspects of soil erosion in this country.—*L. D. Baver.*

Soil Conservation, by H. H. Bennett. 993 pp. New York, the McGraw-Hill Book Co. 1939. $6.00.

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THE CARBON AND NITROGEN METABOLISM OF
STEREUM GAUSAPATUM FRIES[1]

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The importance of *Stereum gausapatum* Fries as a heartrot organism has been well established (3, 10). As previously mentioned (5) this led the writer to carry on studies of the general biology of the organism. The present paper, as the title indicates, is a study of its ability to obtain carbon and nitrogen from various chemical sources.

The cultures used were established from specimens collected at various points in the Eastern United States. The collection data, together with a study of the cultural behavior and characteristics of some of the isolates, has been reported in an earlier paper (5).

CARBON METABOLISM

Bergenthal (1) and others (2, 8) have cultured this fungus on various media but no one has reported any investigation as to its ability to use various compounds as a source of carbon. In order to investigate the ability of this fungus to use various carbon compounds, it was grown on several synthetic media, each offering a different source of carbon.

The media were prepared by mixing, aseptically, a sterile base solution with an appropriate quantity of a sterile solution of the carbon

compound to be investigated. The base solution was of the following composition:

  900.0 cc. H_2O.
  0.5 g. $MgSO_4$.
  0.5 g. KH_2PO_4.
  5.0 g. peptone.
  1.0   drop of 10% aqueous solution $FeCl_2$.
  Sufficient HCl to adjust acidity to pH 5.0.[2]

Forty-five cc. portions of the base solution were autoclaved for 20 minutes at 15 lbs. pressure. Five cc. portions of a 10% aqueous solution of the various carbon compounds were placed in 250 cc. Erlenmeyer flasks and autoclaved for 20 minutes at 15 lbs. pressure. When cool, 45 cc. of the sterile base solution was added, aseptically, to each of the flasks containing the carbon compounds. Each flask thus prepared contained 50 cc. of a 1% solution of the carbon compound in question. Five days were allowed for contaminations to manifest themselves, and then five flasks of each solution were uniformly inoculated with small pieces of mycelium cut from the margin of a vigorously growing malt agar culture of a monosporous mycelium.[3] A similar set of cultures was prepared using an isolate which was started from sporophore tissue.[4] The cultures were incubated at room temperature, in darkness, for 35 days (March 17 to April 21, 1939). The amount of growth was determined by filtering the five cultures of each set through a previously weighed filter paper, rinsing twice with distilled water, and drying at 100° C. Finally, the filter papers with the fungous mats were weighed and the dry weight of the mycelium calculated. The appearance of the cultures was such as to indicate a fair degree of uniformity of growth among the 5 cultures of each isolate growing on each medium.

The essential data of this experiment are presented in Table I.

The only source of carbon in the check was the peptone and a small amount of medium introduced with the inoculum. A comparison of the dry weights of the mycelia of the checks with that produced on the other media leaves no doubt that *S. gausapatum* is able to obtain carbon from all of the compounds tested. Glycerine is obviously of slight value but it did support sufficient growth to be readily observed before filtration and the dry weight is decidedly greater than that obtained on the check medium.

On account of the insoluble nature of cellulose, the above technique could not be employed. Cultures were prepared, however, using the same base solution plus filter paper, cotton cloth, and absorbent cotton, respectively. In every case there was a luxuriant mycelial growth which clearly demonstrated the ability of the organism to obtain sufficient carbon from nearly pure cellulose.

Pure lignin was not available for this study but the writer has observed decay produced by this fungus on several deciduous woods in culture and in every case it produced a typical white rot. In nature, the writer and others (3) have observed that this fungus produces a typical

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[2] The optimum pH for growth lies slightly below this. (6).
[3] This isolate, designated as *isolate* S-12, is described in an earlier paper (5).
[4] This isolate, designated as *isolate* 1, is described in an earlier paper (5).

white rot of deciduous wood. White rots are generally believed to be due to the digestion of the lignin by the fungus (7).

Tannins are aromatic compounds which are abundant in oak wood and more so in oak bark. That tannins may serve as food for *S. gausapatum* was demonstrated by the following experiments.

TABLE I

GROWTH, DURING a 35-DAY PERIOD, OF *Stereum gausapatum* ON SYNTHETIC MEDIA
OFFERING DIFFERENT SOURCES OF CARBON, EXPRESSED IN TERMS
OF DRY WEIGHT OF THE MYCELIUM

CARBON SOURCE	TOTAL DRY WEIGHT OF THE MYCELIUM IN MG. PRODUCED IN FIVE FLASK CULTURES	
	Isolate S-12	Isolate 1
MONOSACCHARIDES:		
Pentoses—		
arabinose	144	155
rhamnose	177	147
xylose	477	438
Hexoses—		
dextrose	354	357
galactose	429	319
levulose	602	371
mannose	454	373
DISACCHARIDES:		
maltose	646	571
sucrose	671	565
TRISACCHARIDES:		
raffinose	439	451
POLYSACCHARIDES:		
glycogen	337	399
inulin	242	251
soluble starch	618	570
NON-CARBOHYDRATES:		
glycerine	89	87
Check: 45 cc. of base solution plus 5 cc. of distilled water	18	42

Tannins are easily extracted by means of hot water (4). To 400 gms. of finely chopped bark of *Quercus velutina* there was added 1500 cc. of tap water. This was heated to 50–80° C. for four hours, allowed to stand for two days, reheated, and then twice filtered. By evaporating 100 cc. of this solution to dryness 3.55 gms. of residue was obtained. A similar procedure was followed using heartwood of the same tree. This extract was found to yield 0.65 gms. of residue per 100 cc. of solution.

A third solution was prepared by adding 1% of tannic acid to a synthetic medium which was carbon free, except for 0.5% of peptone.

Two hundred and fifty cc. Erlemeyer flasks containing 50 cc. portions of the above solutions were sterilized in the autoclave and inoculated from agar cultures of *S. gausaptum*. The cultures were allowed to develop at room temperature. After two months three cultures of each were filtered through a previously weighed filter paper, dried, and weighed to determine the dry weight of the fungous mat. The results were as follows: hot water bark extract, 441 mg. per flask; hot water extract of heartwood, 88 mg. per flask. This technique could not be employed with the tannic acid cultures because of an abundant precipitate which was formed by the reaction of the tannic acid with the peptone. Growth in this culture medium was quite slow, possibly due to the slight availability of the peptone. Upon standing for four months there was considerable mycelium in the flasks. This evidence, in addition to the fact that the fungus grows well on sterile bark or heartwood of *Q. velutina*, strongly indicates that the tannins of oak may be utilized by the fungus. The effect of autoclaving the tannins has not been investigated.

NITROGEN METABOLISM

The ability of fungi to synthesize amino acids from inorganic nitrogen compounds has been under investigation for many years (9). Bergenthal (1) reports that several species of *Stereum*, including *S. gausapatum*, grow equally well on liquid media containing peptone or $(NH_4)_2SO_4$ as the only source of nitrogen. He concludes that the protein is not essential and that the fungus can utilize $(NH_4)_2SO_4$ as a source of nitrogen.

During the present study several attempts were made to culture *S. gausapatum* on media containing nitrogen only as inorganic salts. In every case growth was similar to that occurring on nitrogen-free media. Such experiences led to an attempt to duplicate Bergenthal's results.

Twenty-one 250 cc. Erlenmeyer flasks, each containing 50 cc. of Hagen's medium and a similar set of flasks containing the modified Brown's solution were prepared. The solutions were made up according to the formulae as given by Bergenthal (1). The two liquid media were of the following composition:

1. Hagen's solution.
    1000.00 cc. H_2O.
    5.0 g. glucose.
    0.5 g. $MgSO_4$.
    0.5 g. KH_2PO_4.
    0.5 g. $(NH_4)_2SO_4$.
    10.0 drops of 1% $FeCl_2$ solution.

2. Brown's solution (modified).
    1000.0 cc. H_2O.
    2.0 g. glucose.
    2.0 g. peptone.
    1.25 g. KH_2PO_4.
    0.75 g. $MgSO_4$.

The flasks of media were autoclaved for 20 minutes at 15 lbs. pressure. Twenty-four hours later the pH value of Hagen's solution was found to be 5.0, of Brown's solution, 5.2. In Bergenthal's media the acidities were reported as pH 6.3 and pH 6.1 respectively. The lower pH value reported here is possibly due to a more severe sterilizing process, but Bergenthal does not state how he sterilized his media. Each of the 21 flasks of Hagen's medium was inoculated with a different

isolate of *S. gausapatum*. The cultures used were isolates 1 to 21 inclusive, as described in an earlier paper (5). The 21 flasks of Brown's solution were inoculated in the same manner with the same 21 isolates. The cultures were then incubated in semi-darkness, at room temperature.

A casual periodic observation of the cultures revealed a much better growth on the Brown's medium than on the Hagen's medium. The difference was constant for all of the 21 isolates used. After three months the 21 cultures grown in each medium were all filtered through one filter paper, dried, and the weight of the fungus determined. The total dry weight of the 21 mycelia grown on Brown's medium was 565 mg., while the total dry weight of the 21 mycelia grown on Hagen's medium was only 90 mg. As will be seen later, mycelia grown on media containing no source of nitrogen may show a greater dry weight than was shown by the mycelia growing on Hagen's medium. It is obvious that the isolates of *S. gausapatum* which the author has studied are not able to obtain nitrogen from $(NH_4)_2SO_4$ as effectively as they can from peptone. It does not seem possible that Bergenthal had a strain which differed so greatly in its physiology.

The results presented above together with the fact that no previous work has been reported led to further study of the the ability of *S. gausapatum* to obtain nitrogen from various sources. The fungus was grown on synthetic media using various compounds as the only source of nitrogen. A base solution was made up as follows:

$$1000.0 \text{ cc. } H_2O.$$
$$5.0 \text{ g. } KH_2PO_4.$$
$$2.5 \text{ g. } MgSO_4.$$
$$0.2 \text{ g. } FeCl_2.$$
$$50.0 \text{ g. sucrose.}$$

To one lot of this solution 1% of peptone was added. To other lots appropriate quantities of other nitrogen compounds (Table II) were added. The amount used in each case was such that the solution would contain the same percentage of atomic nitrogen as the 1% peptone solution. The actual quantities added are shown in Table II.

For each compound to be tested five 250 cc. Erlenmeyer flasks, each containing 50 cc. of solution were prepared and sterilized at 15 lbs. pressure for 20 minutes and then uniformly inoculated with a monosporous isolate. After a 30 day incubation period, at room temperature, in semi-darkness, the five flask cultures on each medium were filtered through a previously weighed filter paper and the dry weight of the mycelium determined. The average dry weight of the mycelia grown on the various media are shown in Table II.

The accompanying data indicate that peptone is the only compound tested from which *S. gausapatum* can readily obtain nitrogen. The mycelia growing on media containing asparagine, $NH_4 NO_3$ and NH_4Cl show a slightly greater growth than the check. The difference, however, is not great, and the number of cultures employed is small. It does not, therefore, seem wise to attach any significance to the difference. The slight gain in dry weights of the check and of some others is probably due to (a) the weight of the agar and fungus introduced, (b) the slight growth allowed by the peptone present in the introduced bit of culture and (c) to precipitate formed in the solution. That the first

and third of these factors are of importance is indicated by the dry weight of the mycelia, etc., of the $NaNO_2$ cultures. $NaNO_2$ is so toxic, in the concentration used, that absolutely no growth took place, yet the dry weight of the mycelia, etc., compared favorably with that obtained on certain other media.

In order to investigate the toxicity of the nitrogen compounds a duplicate set of cultures was prepared, in which the media were the same as above except that 1% of peptone was present in addition to the other nitrogenous compound. The fungus appeared to be killed promptly by the solution containing $NaNO_2$, but a luxuriant growth occurred in the presence of all of the other compounds. It is obvious that $NaNO_2$ is very toxic, whereas, the other nitrogenous compounds are not toxic in the concentration used.

TABLE II

GROWTH OF *Stereum gausapatum* IN 30 DAYS ON SYNTHETIC MEDIA OFFERING
VARIOUS COMPOUNDS AS SOURCES OF NITROGEN EXPRESSED
IN TERMS OF DRY WEIGHT OF THE MYCELIA

Source of Nitrogen	Amount, in gms., of N-compound Added to 1 Liter of Base Solution	Average Dry Weight, in mgs., of Mycelium per Flask
Peptone	10.00	541
Asparagine	7.25	60
NH_4NO_3	4.50	55
NH_4Cl	6.75	59
$(NH_4)_2SO_4$	7.75	35
KNO_3	11.50	22
$NaNO_3$	9.75	36
$NaNO_2$	8.00	28
Check	0.00	35

SUMMARY AND CONCLUSIONS

The ability of *Stereum gausapatum* Fries, important cause of heartrot of oak, to use carbon and nitrogen from various sources has been investigated.

The fungus was found to grow well in culture with the following compounds as the only source of carbon: xylose, dextrose, galactose, levulose, mannose, maltose, sucrose, raffinose, glycogen, inulin and soluble starch. Rhamnose and arabinose were much less effective and glycerine was found to be of very little value but did support some growth. That lignin and tannins may serve as food for the fungus is indicated by various experiments and observations.

Synthetic media containing peptone supported a heavy growth of mycelium but when the nitrogen was furnished only

in the form of inorganic salts (NH_4NO_3, NH_4Cl, $(NH_4)_2SO_4$, KNO_3, $NaNO_3$, $NaNO_2$) or asparagine growth was not significantly greater than on a nitrogen-free medium. The fungus is therefore not able to use appreciable amounts of nitrogen from such inorganic compounds. $NaNO_2$ is definitely quite toxic. The other compounds were shown to be non-toxic.

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Fleas of Eastern United States

The last taxonomic revision of the order Siphonaptera appeared in 1904. Since then various authors have contributed many short and scattered articles on the subject, but it remained for the author of this book to bring together all this information into one volume.

The scope of the work is confined to a consideration of the species occurring east of the one-hundredth meridian with the exclusion of Texas. In this area are known to occur five families, comprising thirty-three genera and fifty-five species. Present knowledge indicates that they are parasitic on about seventy-five mammalian and avian hosts including man and domestic animals. Keys to suborders and genera are included. There are thirty-one plates of drawings illustrating morphological characters used in species separation.

Preceding the taxonomic presentation is a chapter on collecting, preserving, morphology, terminology, life history and control of fleas. Besides the usual index at the end of the book there is also a synonymic index and a host index. A selected bibliography is appended.

The book has been used by students in the medical entomology class for determining some unidentified specimens and has been found to be very satisfactory. The descriptions are very complete and the illustrations excellent. This book is a worthwhile and valuable addition to the library of every entomologist and should be a handy reference for the medical man and veterinarian as well.

—*R. H. Davidson.*

Fleas of Eastern United States, by Irving Fox. vii+191 pp. Ames, Iowa, The Iowa State College Press. 1940. $3.00.

NEW AND RARE SPIDERS FROM THE GREAT SMOKY MOUNTAIN NATIONAL PARK REGION

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Family AGELENIDAE

Coras cavernorum, new species
(Figure 1)

Female.—Total length 13 mm. Cephalothorax 6 mm. Abdomen 7 mm. Cephalothorax widest part between second and third leg, 4 mm. Cephalothorax at eye region, 2.6 mm. Width of posterior lateral eyes, 1.6 mm. Length of first leg, 20 mm.

Cephalothorax with the usual markings. A dark line from posterior lateral eyes to an elongated hexagonal light area which has its posterior point on the outside of a dark hexagonal area which ends lateral to the dorsal groove. A faint line from posterior middle eyes to the elongated light hexagonal area. The anterior angle of this area bisected by a dark line which is an extension of the line from the posterior lateral eyes.

Anterior part .of head a rich yellowish brown. This color becomes lighter toward the posterior edge of the cephalothorax where it is lemon color.

The legs are the same color as the head except the distal end of femur and the patella which are lemon. Faint bars show on the upper side of femora and tibiae. The femora underneath show three well marked dark bars; the first or basal is narrow; the second or middle bar and the subapical are broad.

Abdomen a dark greenish gray. The indefinite pattern is made up by the underlying white which shows through. A basal dark stripe extends half the length of the abdomen. It is broken in the middle by a white spot between two muscle impressions. On the posterior part. are five chevrons. The two anterior are broad and irregular flocculent white spots. The three posterior are inverted V marks, each made up of a single row of small white dots. Just above each posterior spinner-ette a long white horizontal dash mark.

Venter of abdomen with a long dark shield-shaped center broken by two small white spots just below the epigynum. The dark center is surrounded by large irregularly placed white spots. Sides of venter dark with small white dots.

Epigynum wide, but narrow from front to back.

Sternum dark with a central light line which nearly meets a pos-- terior light diamond mark.

One female from a small cave six miles west of Waynesville, N. C., at 3500 ft. September 30, 1936. A. Stupka Coll.

Family LEPTONETIDAE

Leptoneta gertschi, new species

(Figure 2)

Male.—Length 1.4 mm.

The ground color is yellowish white overlaid by a granular brownish purple. The darkest parts are the sternum, edges of thorax, venter and sides of the abdomen. The dorsum of the abdomen shows a faint light herring-bone pattern.

The palp on the outside shows a characteristic set of spines (Fig. 2). A terminal projection of the cymbium bears in a pit a flattened spine of peculiar shape. Behind this with its origin near the base of the projection is a long delicate hair. A small papilla proximal to the constriction of the tarsus bears four delicate spines one of which is broadened and flattened, spatula-like at the end. These spines are followed by two large forward curving spines in front of which there is a delicate straight spine. The anterior edge of the tibia bears five spines in a group. The upper which is heavy and flattened at the base is longer than the tarsus and patella together. The others from a half to a third the length of the upper.

The inside of the palp shows below the constriction in the tarsus a small brownish chitinized patch shaped like the wing-cover of a beetle. Below this patch there is on the front edge of the bulb a fan-shaped group of six or seven straight hairs directed forward.

Two males. Greenbrier section of Great Smoky Mountain National Park, Tenn. June 14, 1939. (Sifting leaves.)

Leptoneta coma, new species

(Figure 3)

Male.—Length 1.52 mm.

The color and general conformation is like the species silvicultrix and gertschi but the males can be easily distinguished by the palp and its peculiar specialized hairs and spines.

The tarsus of the palp is deeply cleft at the distal end forming an upper and lower lobe. Seen from the outside the lower lobe is nearly as large as the upper but bears on its lower side a secondary lobe or knob (Fig. 3) which bears a small black flattened spine set in a pit. The upper lobe has the usual long hairs of which four stand out as being heavier than the others. The middle lobe bears on its upper edge a long delicate hair below which are several short hairs, the lower one plumose. Proximal to the constriction in the tarsus is the usual series of spines one of which is flattened slightly. The most distinctive feature of the palp is a series of eight extremely long hairs which arise along a vertical line on the middle of the inside of the bulb and extend forward side by side beyond the middle lobe of the tarsus. These are white at the tips. The tips of four are shown in the figure. The specific name refers to this wisp of long hairs.

Two males. Seven females. Gatlinburg, Tenn. June 21, 1936. Sifting leaves near the river.

Family THERIDIDAE

Theridium sex-setosum, new species

(Figure 4)

Male.—Length 1.4 mm.

Thorax black except for two pale tan streaks which extend from below the anterior lateral eyes around the sides to the posterior declivity where they end abruptly. The lower edge of the thorax back of the first legs milk white. Sternum brownish tan.

Abdomen black with markings as follows: on the dorsum two pairs of round white spots each surrounded by a pale parchment-like area; above the spinnerettes several white spots which form a rough triangle pointed downward. Lower sides of abdomen with a long white spot. Venter brownish black with a pair of small white spots in the middle.

Legs pale transparent with black hairs.

Palps pale to the end of the tibia which is black. Tarsus of palp tan.

Between the two rows of eyes are six black erect robust spines evenly spaced. These are about as long as the clypeus is wide. The anterior tibia bears at the center of its inner face a robust tapering spine which is almost half as long as the segment itself.

Palpal organ outside view as shown in Fig. 4.

One male. Headquarters Area of Great Smoky Mountain National Park, Tenn. June 12, 1939.

Theridium ambitum, new species

(Figures 5 and 5A)

Male.—Length 1.25 mm.

The pedicle is inserted on the abdomen behind the middle in such a way that the abdomen is vertical in position.

The forelegs are very long (3 mm.), the fourth pair short (1.5 mm.).

The cephalothorax short and almost as broad at third legs as it is long. The anterior edge is broadly rounded, the clypeus vertical retreating almost as high as the chelicerae are long. In profile the cephalothorax rounds up from the posterior margin and becomes horizontal at its highest point at the posterior eye row.

The colors are: Legs pale white contrasting strongly with black spines and hairs. Cephalothorax yellowish white faintly lined with greenish gray. Abdomen white clouded more heavily toward the spinnerettes with grayish green, but showing some small white spots. Spinnerettes white.

The distal end of the first tibia on its inner face bears a short spur from the top of which arises a heavy black slightly curved spine. From the base of the metatarsus there arises a small spine which is directed slightly downward in such a way that when this joint is flexed the smaller spine makes contact with the upper edge of the larger spine. (Fig. 5A.)

The palpal organ is broad and flat except at the distal end where the cymbium is elongated and bent downward at an angle of 85°. This extension of the cymbium is coiled into a trough which carries the black tips of the embolus and conductor. (Fig. 5).

One male. Laurel Falls Trail, Great Smoky Mountain National Park, Tenn. June 15, 1939. (Sifting in pine needles.)
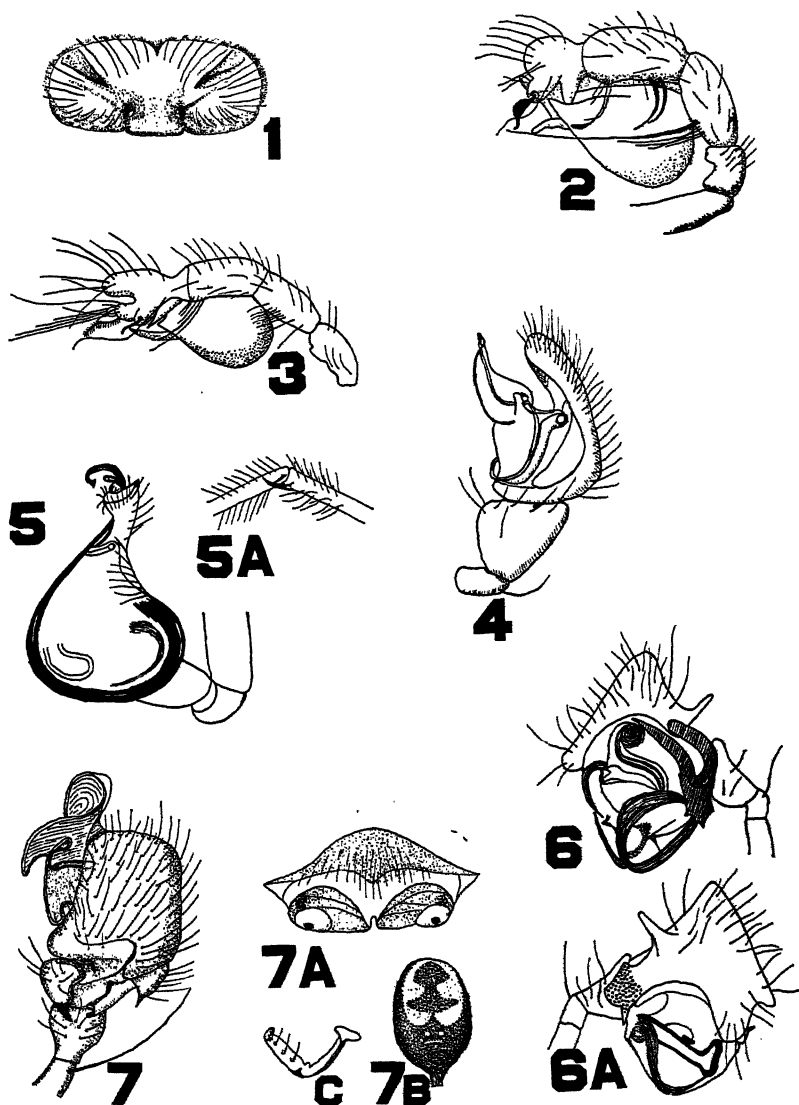
Fig. 1. Coras cavernorum, epigynum.
Fig. 2. Leptoneta gertschi, outside view of left palp.
Fig. 3. Leptoneta coma, outside view of left palp.
Fig. 4. Theridium setosum, outside view of left palp.
Fig. 5. Theridium ambitum, ventral view of left palp. 5A. Inside view of right tibio-metatarsal joint.
Fig. 6. Bathyphantes officiosus, outside view of left palp. 6A. Inside view of same.
Fig. 7. Lepthyphantes ornithes, left male palp. 7A. Epigynum. 7B. Female abdomen showing pattern from the dorsal view. 7C. Paracymbium.

Family LINYPHIIDAE

Bathyphantes officiosus, new species

(Figures 6 and 6A)

Male.—Length 1.75 mm.

Thorax yellowish clouded with black which forms a dark margin.

Legs light yellow. Bases and undersides, particularly the coxae white.

Sternum yellow clouded with black, particularly the posterior edge.

Abdomen greenish black with a white middle cross band which slopes backward on each side but does not reach the venter. Venter black.

Chelicerae swollen at base, much constricted distally, the fang groove broad, flat, excavated laterally, without teeth.

The palpal organs are shown in Figs. 6 and 6A.

Two males. Headquarters area, Great Smoky Mountain National Park, Tenn. June 14, 1939.

Lepthyphantes ornithes, new species

(Figures 7, 7A, 7B and 7C)

Male—Length 2.5 mm. First tibia 2.5 mm. First metatarsus 2.4 mm. First tarsus 1.1 mm.

Cephalothorax pale orange yellow somewhat clouded by gray along the edges.

Legs pale orange yellow.

Abdomen pale yellow with an overlaid pattern of gray somewhat obscure but showing the peculiar "bundle of wheat" mark easily seen on the two darker females. (Fig. 7B.)

Sternum and venter of the abdomen darker than dorsum. Sternum longer than wide (15 : 14) straight across the front or slightly reentrant, widest between coxae I and II slanting directly to the rather broad extension between the hind coxae.

The palpal organ (Fig. 7) is atypical in three respects: the embolus is long and follows the edge of a broad membranous fold; the base of the cymbium is excavated, the excavated portion partially covered by an innerfold and an outerfold and grooved tooth; the usual apophyses are either absent or very much reduced.

The paracymbium is fairly typical for this genus. (Fig. 7C.)

Female.—The two females at hand are much darker than the male, the legs being dusky and the abdomen almost black and white (Fig. 7B). The epigynum (Fig. 7A) appears as if made up of two gasteropod shells with the large openings toward the abdomen. When seen from behind the two parts appear as two bird heads placed beak to beak.

Male and female. Sugar Grove, Ohio, Oct. 26, 1918. Under a log in a wooded ravine.

Female. Little River, Great Smoky Mountain National Park, Tenn. Sept. 3, 1936.
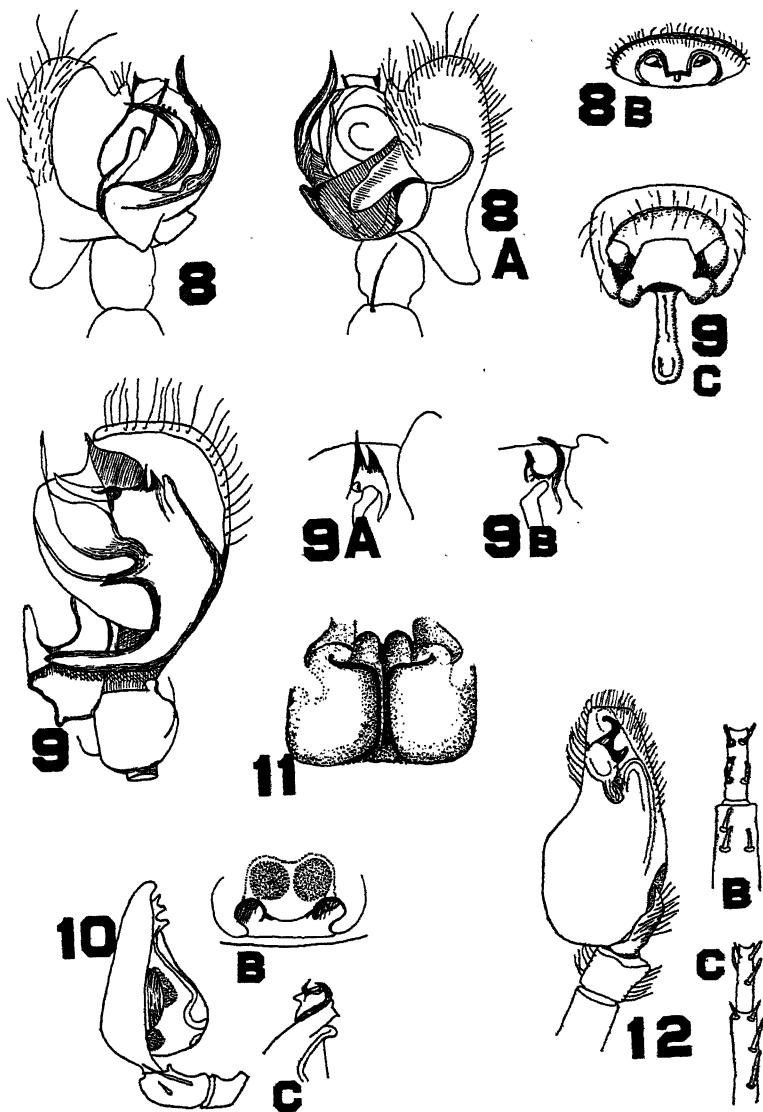
Fig. 8. Microneta olivena. 8 and 8A. Two views of right palpal organ.
8B. Epigynum.
Fig. 9. Microneta tennapex, palp. 9A. Black teeth on end of palp to be compared
with 9B similar teeth in Microneta latidens Em. 9C. Epigynum.
Fig. 10. Castianeira stupkai, inside view of left palp. 10B. Epigynum. 10C. Dorso-
mesial view of embolus and conductor.
Fig. 11. Liocranoides unicolor, epigynum.
Fig. 12. Pseudicius lecontei, left palp. 12B. Left foreleg, ventral view showing
spines on tibia and metatarsus. 12C. Left second leg, ventral
view, showing spines on tibia and metatarsus.

Microneta olivena, new species

(Figures 8, 8A and 8B)

Male.—Length 1.5 mm.

Cephalothorax above and below pale buff clouded with sooty black without a definite pattern except a darker edge.

Legs pale buff.

Abdomen above and below dark gray.

Eyes on black spots.

Sternum squarely truncated across the front and widest between the first and second coxae. It is moderately bowed ventrally.

The palp (Figs. 8 and 8A) is much like that of Emerton's Microneta olivacea.

Female.—Length 2 mm.

Color and general configuration like the male. Through the kindness of Miss E. B. Bryant I have been able to examine male and female specimens of Microneta olivacea from Mr. Emerton's collections taken on Mt. Mansfield, Vt. June 17, 1909. The epigynum of olivacea is short and thick while in olivena it is long and more narrowly oval in cross section as indicated in Fig. 8B.

One male and one female. Camp No. 1 near Gatlinburg, Tenn., Great Smoky Mountain National Park, Tenn. Mar., 1937.

Microneta tennapex, new species

(Figures 9, 9A, 9B and 9C)

Male.—Length 2 mm.

The general color is a pale dull yellow clouded with sooty black.

Cephalothorax edged with black with the usual radiating lines and median line.

Eyes on jet black spots. The spots surrounding the posterior median eyes extend posteriorly into fine sharp points.

Sternum and venter are dusky but smooth and shiny.

Coxae and trochanters pale yellow as are the patellae, metatarsi and tarsi. Femora clouded distally as are the tibiae.

Chelicerae have on the outer lateral surface a double or triple row of very short stiff closely packed spines which extend from the cheliceral base almost to the base of the fang. This group of spines looks like a black cheliceral line.

Female.—Same size and marked exactly like the male except that the abdomen shows a few small white spots widely separated. These appear to be in four longitudinal rows.

This species seems to be quite like Emerton's *Microneta latidens.* Through the kindness of Miss E. B. Bryant I have been able to compare these specimens with some specimens of *Microneta latidens* which were taken at Newton, Mass., on Nov. 22, 1904. Fig. 9B shows the two peculiar palpal spines of *M. latidens.*

Figs. 9, 9A and 9C show the palpal organ and epigynum.

Several males and females, Summit of Clingman's Dome, Great Smoky Mountain National Park, Tenn. Mar. 19, 1937.

Family Clubionidae

Castianeira stupkai, new species
(Figures 10, 10B and 10C)

Male.—Length 8 mm. Cephalothorax 2.6 mm. Abdomen 2.4 mm. General color golden orange suffused with reddish brown.

Cephalothorax elliptical, widest at the second coxa, high evenly rounded from side to side, rising from the posterior border to a point just back of the head then falling slightly to the eyes. The clypeus is vertical or slightly retreating as wide as the eye area. Anterior eye row slightly procurved the medians separated by one third the diameter of one, the lateral eyes almost touching the medians. Seen from above the anterior eye row is recurved; the second eye row wider then the first, slightly procurved, the medians separated by a diameter, close to the laterals. Each eye is narrowly surrounded by black. Dorsum of the cephalothorax faintly marked with minute reddish spots growing more intense in color toward the borders. The chelicerae are about as long as the head is high above them. They are uniformly swollen somewhat retreating; the furrow of the chelicerae with two teeth above and two below. The distal tooth of each group is large, an equilateral triangle, the more proximal smaller.

Sternum yellow longer then wide with a few dark hairs directed inward.

First leg dark up to the middle of the femur, yellow to the base of the metatarsus. The metatarsus is dark, the tarsus white. Fourth leg darkened except for the extreme distal end of the tibia and the tarsus which are white.

Abdomen narrow anteriorly gradually widening to the three quarter mark where it is widest. From this point it is evenly rounded across the end. The dorsum is darkened with red dots and covered with golden hairs except for two rings of white hairs, the first at the distance of one fifth from the anterior end, the second at the two fifths mark. There is some evidence of a pair of white spots behind the second ring. The white rings run down the sides but do not cross the venter. The anterior seven eighths of the dorsum of the abdomen is covered by a shiny thin scutum which is detected with difficulty. This is flat, rectangular, and smooth. Just in front of the spinnerettes is a large tuft of thickly set erect black hairs longer than the spinnerettes and occupying about the same space.

The palps are darkened. The palpal organ as illustrated (Figs. 10 and 10C).

Female slightly larger than the male due to the increased size of the abdomen, colored and marked like the male except that the front metatarsus is not darkened. The white tip of the posterior tibia is missing; and the abdomen shows two basal white marks. The scutum on the abdomen is basal, nearly square, half as wide as the abdomen.

The epigynum (Fig. 10B) shows the usual two openings.

Male. Gatlinburg, Tenn. June 25, 1936. (In Andropogon field.)

Female. Gatlinburg, Tenn. May 21, 1937. Glen Sheets Coll.

Liocranoides unicolor, Keys

(Figure 11)

Female.—Length 9 mm.

Except for the epigynum which is shown in Fig. 11 Keyserling's description is adequate for this species.

Female. Great Smoky Mountain National Park, Tenn. Sept. 17, 1937. (Under rock on hillside above C. C. C. Camp.)

Family ATTIDAE

Pseudicius lecontei, new species

(Figures 12, 12B and 12C)

Male.—Length 3.5 mm.

General color blackish lead partially covered with large irridescent scales showing white, pink or green colors.

Thorax low flattened sloping upward from the anterior eyes in a rounded curve to the point where the posterior declivity descends sharply. Thorax widest just in front of the posterior declivity.

Eye area darker than the remainder of the cephalothorax. The quadrangle of the eyes wider behind. The third eyes very small, nearer the second row. The anterior row seen from above recurved, the laterals about one-fourth the diameter of the medians. Thorax has a marginal band of white hairs and a wider sparse supra-marginal band which starts at the anterior median eyes and passes around to the edge of the posterior declivity.

Abdomen elongated overlapping the thorax in front, widest at the middle, narrowing to a point at the spinnerettes. Dorsum covered with irridescent scales but showing a short white basal band.

Bases of the legs, sternum and venter are lead black with a few irridescent scales.

The palps are dull black above and below but are tipped with white. The first leg is somewhat enlarged; the femur, tibia and tarsus dark, the patella is lighter, and the metatarsus white. The three remaining legs have the femur dark. The patellae and tibiae are dark above and below but have heavy stripes of large white scales running along the anterior and posterior edges. The metatarsi are white with a distal black ring. The tarsi are white. In the sunlight the lines of scales on the patellae and tibiae (Ohio specimen) glow with a bright cerise pink color giving the impression that the spider is surrounded by a pink picket fence.

The anterior margin of the cheliceral groove bears one small black tooth distant from the fang base. The posterior margin bears a similar large triangular tooth. The spines on tibia I (Fig. 12B) are (1, 0), 2, metatarsus 2, 2; tibia I (Fig. 12C) 2, 1, 1, metatarsus 2, 1 plus 1 anterior lateral.

The fang shows a basal half thickened, opaque, and a distal narrowed region clear enough to show the poison duct. Palpal organ as figured (Fig. 12).

One male. Top of Mt. Leconte, Great Smoky Mountain National Park, Tenn. Aug., 1937.

One male. Higby, Ohio. (From a dry wash) June 19, 1931.

NOTES ON SOME OHIO APHIDS[1]

CLYDE F. SMITH

Assistant Entomologist

While collecting aphids and parasites in Ohio during the years 1936–1939 the writer has found two species of apparently undescribed aphids. He has also collected several species which have hitherto been unrecorded for Ohio. It is deemed advisable to publish the records and the descriptions of the new species in order to have names to use in recording the parasites, and to add to the list of Ohio Aphidae.

The following list was prepared as a supplement to the lists published by Guyton (Ohio Jour. Sci. 24: 1–30, 1924) and Cutright (Ohio Jour. Sci. 25: 313–314, 1925). Unless stated otherwise the following material was collected in Ohio by the writer.

Essigella pini Wilson. Hocking County, June 26, 1938, on *Pinus virginiana*.

Cinara tujafiliana (Del Guercio), Columbus, August 14, 1937, on Arborvitae (N. F. Howard; R. H. Davidson).

Unilachnus parvus (Wilson). Monroe County, July 23, 1938, on *Pinus* sp. and Hocking County, June 26, 1938, on *Pinus* sp.

Saltusaphis scirpus Theobald. Logan County, June 23, 1938, on *Scirpus* sp.

Plocamaphis flocculosa (Weed). Columbus, June 19, 1938, on *Salix* sp.

Aphis acritus n. sp.[2]

Alate vivipara.—Color dark greyish-black, only slightly pulverulent; antennae, metathoracic legs, cornicles and cauda dark, pro- and meso-thoracic legs paler; (cleared specimens) head and thorax dark, abdomen with dusky areas about the base of the cornicles, between the cornicles and cauda, along the sides of the body and with a few smaller dark areas down the middle of the back. Body 1.77[3] (1.57–1.96); hairs on

vertex, abdomen and tibiae .02; antennae 1.57 (1.44–1.6); antennal III, .40 and bearing 40 sensoria; IV, .26 and bearing 11 sensoria; V, .22 and bearing 1 secondary sensorium; VI, .14 plus .36; rostrum attaining first abdominal segment; rostral IV plus V, .12; hind tibiae .94 (.93–.96); hind tarsi .15; cornicles .17; cauda .09 for the hard portion and .15 total length.

Collections.—Holotype and 3 paratypes (alate vivipara) collected at Columbus, Ohio, June 17, 1938, on *Sedum* sp. Collections of alate vivipara were also made on the same plant June 10, 1938, (2 specimens) and October 7, 1938 (1 specimen).

Apterous vivipara.—Color greyish pulverulent, nymphs yellowish; legs and antennae slightly lighter than in the alate vivipara; cornicles and cauda dark; (cleared specimens) head slightly dusky; thorax pale; abdomen with a large dark patch between the cornicles and cauda and a few very small patches on the dorsum and sides. Body 1.72–1.85; hairs on vertex .034; antennae 1.41–1.64; rostrum attaining first abdominal segment; rostral IV plus V, .12–.13; hind tibiae .86–.94; hind tarsi .15; cauda .11–.12 for hard portion, .17–.18 total length.

Described from 6 paratypes collected with the holotype, and 5 paratypes in the June 10 collection.

Apterous ovipara.—Color as in apterous vivipara. Antennae 1.27–1.30; antennal III, .28; IV, .22; V, .2–.23; VI, .12–.13 plus .31–.33; rostrum attaining first abdominal segment; rostral IV plus V, .11; hind tibiae .73–.80; hind tarsi .14; cornicles .17–.19; cauda .11 for the hard portion, .14–.16 total length.

Collection.—On *Sedum* sp. at Columbus, Ohio, Oct. 7, 1938 (21 specimens). This collection was made on the same plant the holotype was collected from.

Alate or Apterous males.—Color very similar to alate vivipara. Body 1.09–1.58; antennae .97–1.58; rostral IV plus V, .08–.10; hind tibiae .56–.86; hind tarsi .09–.12.

Collection.—6 alate and 1 apterous specimens collected with the apterous ovipara.

Taxonomy.—*Aphis acritus* differs from *A. rumicis* in having more sensoria on the antennae of the alate vivipara. The alate vivipara of *A. rumicis* may have a relatively large number of sensoria (20–23) in the fall forms, however, the writer knows of no case where the spring forms have this many. In *A. acritus* the number of sensoria seem to be fairly constant in the spring and fall forms of the alate vivipara. *A. acritus* also differs in the senoria being more tuberculate in alate vivipara; in bearing fewer hairs on the cauda; and in the shape of the hind tibiae of the apterous ovipara and the number and arrangement of the sensoria.

Aphis dibilicornis (Gillette and Palmer). Columbus, September 22, 1937, on *Helianthus tuberosus.*

Aphis frangulae Kaltenbach. Columbus, October 8, 1936, *Nepeta cataria.*

Aphis medicaginis Koch. Columbus, June 19, 1938, on sweet clover.

Aphis neogillettei Palmer. Columbus, May 1, 1938, on *Cornus* sp.

Aphis nyctalis Hottes and Frison. Hocking County, May 1, 1937, on *Senecio* sp.

Aphis oestlundi Gillette. Columbus, May and June, 1938, and Monroe County, July 23, 1938, on *Oenothera*.

Aphis saliceti Kaltenbach. Columbus, June and July, 1938, on *Salix* sp. Also in Pickaway County, July 7, 1938 (J. S. Caldwell).

Amphorophora ribiella (Davis) Columbus, June 18, 1938, on *Ribes* sp.

Capitophorus braggii (Gillette). Delaware County, October 9, 1938, and Columbus, October 2 and 14, 1938, on thistle.

Capitophorus gillettei Theobald. Columbus, October 14, 1938, on *Polygonum* sp.

Capitophorus ohioensis n. sp.[4]

Apterous vivipara.—Color greenish appearing overcast with greyish-white because of numerous fan-shaped or capitate hairs, antennal I, II and basal ⅔ of III concolorous with head, remainder of antennae dark brown to black; legs pale, shading to brownish on the tibiae and tarsi; cornicles light brownish; cauda pale. Length of body 2.19 (2.11–2.35); hairs on vertex (.02–.04); hairs on antennal III, 0.1; antennae 2.86 (2.67–3.14); antennal III, .61 and bearing 2 or 3 sensoria; IV, .50; V, 43; VI, .15 plus 1.02; rostrum attaining second pair of coxae; rostral IV plus V, .11 (.10–.12); hind tibiae 1.30 (1.30–1.38); hind tarsi .15; cornicles .42 (.42–.51); cauda .23 (.23–.28) for the hard portion and .31 (.28–.34) for the entire length.

Described from the holotype and 3 paratypes taken on the underside of leaves of *Helianthus* sp. at Columbus, Ohio, October 15, 1938.

Apterous ovipara.—Color same as apterous vivipara described above; body (2.04–2.50); hairs on vertex (.03–.04); hairs on antennal III, .01; antennae (2.37–2.74); rostral IV plus V, (.11–.12); hind tibiae bearing 65 to 75 sensoria; hind tarsi .15; cauda (.17–.22) for the hard portion and (.23–.26) total length.

Described from 37 paratypes taken with the holotype.

Alate male.—Appendages somewhat darker than the apterous vivipara; body 1.41 (1.41–1.57); hairs on vertex .03; antennae 2.50; antennal III, .51 (.51–.53) and bearing 35–41 (27–43) sensoria; IV, .50 (.50–.52) and bearing 28–30 (22–30) sensoria; V, .39 (.39–43) and bearing 18–21 sensoria; VI, .12 (.12–.14) plus .81 (.78–.81); rostral IV plus V, .09 (.09–.11); hind tibiae 1.19 (1.18–1.22); hind tarsi .15; cornicles .15; cauda (.07–.12) for the hard portion and (.12–.18) total length.

Described from allotype and 2 paratypes taken with the holotype.

Holotype, allotype and a few paratypes to be deposited in the U. S. National Museum, paratypes in the collection of the writer.

Taxonomy.—*C. ohioensis* resembles *C. wasatchii* Knowlton from which it differs in cornicles being longer than antennal V in the apterous vivipara and in the body hairs being longer and having a more distinct shaft. The body hairs on *C. wasatchii* are much denser and more conspicuous than in *C. ohioensis*.

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[4]The writer wishes to express his appreciation to Dr. G. F. Knowlton for his opinions concerning this species.

Macrosiphum ambrosiae (Thomas). This species is common throughout the state and was collected on *Helianthus* sp., *Solidago* sp. and *Sonchus* sp.

Macrosiphum coryli Davis, Hocking County, June 26, 1938, on *Corylus* sp.

Macrosiphum illini Hottes and Frison. Columbus, August, September and October, 1938, on *Helianthus* sp.

Macrosiphum niwanista (Hottes). Columbus, July 9, 1938, on *Solidago* (?).

Hamamelistes spinosus Shimer. Columbus, May 12, 1938, and May 20, 1939, on *Betula* sp. This aphid was seriously damaging a young birch tree that was being used for ornamental purposes.

Littoral Fauna

Civilized man lives in an environment which differs from that experienced by all other animals. He plunges almost from birth into a world of objects with labels. His first nursery school text shows a cat, a dog or other object underneath each of which is its printed name. Eventually he learns that language is a system of vocal labels or written labels which can be juggled into sentences, paragraphs and even into written book notices. He soon realizes that life can become very embarrassing if he forgets and mixes labels, and refers to a girl friend as a lemon. He lives in a world of labels. He soon thinks labels.

Curiously enough he tends to avoid objects whose names or labels are unknown to him. Unnamed objects confuse his thinking, or actually make certain types of thought (word juggling) difficult or even impossible.

Hence the pleasure one derives from such a volume as the one before us. Miss Eales, Lecturer in the Zoology Department of the University of Reading, has given us just such a label-fixing work. It keys out and puts names, at least down to genera, on the fauna of the between-tide zone of the shores of the British Isles. As she states herself: "Its object is three-fold: (1) To encourage observation of the habitat, habits and structure of the living animal, (2) To supplement with a closer observation in the laboratory, and (3) To provide a preliminary training in systematic work.

British land life is very meager because of the recent glaciation and the difficulty of spread from the south across the North Sea and the Channel and over mountain ranges that fringe the Mediterranean basin. The littoral fauna appears to have been less disturbed perhaps because of its association with the warm Gulf Stream and its direct connections with more southern continental shores. It is a fairly rich life. Comparative anatomy and systematic zoology started their modern development on these very shores. It was this fauna which enthused Cuvier when, as a tutor in the family of the Compte d'Héricy during the French revolution, he lived with that family at Fécamp near Havre on the Channel. His spare hours were spent collecting and dissecting these curious animals. The great English students of the invertebrates were trained on this same fauna.

The material is handled in thirteen Phyla. This conservative taxonomy is carried throughout the book. Thus the ninety per cent of common species are named to species while the accidentals, local and rarer forms, are not given specific treatment. Each phylum section opens with a short bibliography of monographic works on that group. Keys are moderately simple and anatomical terms are taken care of by numerous labels on the many plates of simple line drawings.

The volume gives the student a balanced picture of a North Atlantic seashore fauna. It is satisfying in this matter of putting labels on objects which are usually without names to even the seashore student of zoology. It is well done and by an experienced student of shore life.—*C. H. Kennedy.*

The Littoral Fauna of Great Britain, by N. B. Eales. xvii+300 pp. Cambridge, at the University Press; in New York, the Macmillan Co. 1939. $3.50.

SPIDERS AND INSECTS FOUND ASSOCIATED WITH SWEET CORN WITH NOTES ON THE FOOD AND HABITS OF SOME .SPECIES

V. HOMOPTERA AND SUMMARY

RAY THOMAS EVERLY

Holmesville, Ohio

HOMOPTERA

This order was represented in the field chiefly by the family *Cicadellidae*. However the determinations of this family have not been received and, rather than delay further the completion of this paper, it was decided to present the remaining species of this order. Determinations were made by Mr. J. S. Caldwell, Mr. W. D. Funkhouser, Mr. P. W. Mason and Mr. P. W. Oman.

APHIDIDAE

Aphis maidis Fitch—Ten specimens taken from July 28 to August 8.
An undetermined species of aphids was observed upon an unopened tassel attended by *Formica fusca subsericea* Say, (Hymenoptera-Formicidae). When adult Coccinellid beetles were placed in the close vicinity of the aphids, the ants immediately rushed them and knocked the beetles from the plant.

CHERMIDAE

The specimens in this family have been previously reported by Mr. J. S. Caldwell in the Chermidae of Ohio. (Ohio Biological Survey Bulletin No. 34, Vol. VI, No. 5, Jan., 1938, pp. 241 and 235).

Aphalara veaziei Patch...One specimen collected July 10.
Livia opaqua Cald.......One male specimen taken July 18.
This specimen is the male holotype of the species.

CICADELLIDAE

Seventy-eight specimens were collected of this family representing an unknown number of species. Many were very abundant upon the corn plants. When, and if determinations for this group are received they will be presented in a separate paper.

DELPHACIDAE

Delphacodes sp. probably *lateralis* Van Duzee—One specimen taken July 31.

FULGORIDAE

Five specimens of this family were collected. These represented four distinct species. The accurate determinations of these can not be made as the specimens have become lost.

MEMBRACIDAE

Atmya querci Fitch.........One specimen taken July 6.
Campylenchia latipes Say...One specimen taken July 10.
Enchenopa binotata Say.....Three specimens collected July 11 and 12.
Micrutalis calva Say........Two specimens collected July 10 and 11.
Similia camebis Fab........One specimen taken July 5.

SUMMARY

This paper has presented a list of the species of insects and spiders collected within the limits of a four acre field of sweet corn. The list is far from a complete one due to lack of time to make more intensive collections and the limited collecting apparatus which could be carried, but it is a representative sample of the arthropod population of the field and is indicative of the tremendous numbers of species supported by the corn plants and the extraneous plants found in the field.

The four previous parts of this paper appeared as follows:

Part   I—Arachnida and Coleoptera. Ohio Journal of Science, Vol. 38, No. 1, May 1938, pp. 136-148.

Part II—Ephemerida, Lepidoptera, Neuroptera, Odonata, Orthoptera, Thysanoptera, and Trichoptera. Ohio Journal of Science, Vol. 38, No. 6, Nov. 1938, pp. 311-315.

Part III—Hymenoptera. Ohio Journal of Science, Vol. 39, No. 1, Jan. 1939, pp. 48-51.

Part IV—Diptera and Hemiptera. Ohio Journal of Science, Vol. 39, No. 1, Jan. 1939, pp. 52-56.

Table I gives the distribution of the specimens collected among the various orders of spiders and insects.

In addition to recording the species present in the field, the following food plants and prey records were observed and collected:

ARACHNIDA

Phidippus sp. (immature).........Spider, *Tetragnatha laboriosa* Htz.

COLEOPTERA

Canthon pilularius L..............Horse manure.
Ceratomegilla fuscilabris Muls......Plant bug, *Trigonotilus ruficornis* Geof.
                                    Pollen of sweet corn.
                                    Eggs of European Corn Borer, *Pyrausta nubilalis* (Hbn.)
Chrysopus auratus Fab............Dogbane, *Apocynum cannabium* L.
Cicindela punctulata Oliv..........Ground beetle, *Tachys incurvus* Say (?)
Diabrotica duodecempunctata (F)....Anthers of wild rose.
                                    Silk of sweet corn.

Epicauta pennsylvanica DeG.......Pollen of sweet corn.

Glisochrochilus quadrisignatus Say...European Corn Borer, *Pyrausta nubilalis* (Hbn.)

Tetragonoderus fasciatus Hald......Black nightshade, *Solanum nigrum* Nutt.

TABLE I

Class and Order	Families	Genera	Species	Specimens
INSECTA:				
Coleoptera..............	27	105	145	963
Diptera................	24	47	50	114
Ephemerida.............	1	1	1	3
Hemiptera.............	10	21	23	95
Homoptera.............	6	10*	13*	99
Hymenoptera...........	21	48	60	95
Lepidoptera............	11	25	29	45
Neuroptera.............	2	2	4	10
Odonata................	2	2	2	2
Orthoptera.............	4	8	9	26
Thysanoptera...........	2	2	2	2
Trichoptera............	1	1	1 .	1
Total Insects........	111	272	339	1,455
ARACHNIDA:				
Araneida...............	9	25	32	50
Grand Total........	120	297	371	1,505

*Exclusive of Cicadellidae.

DIPTERA

Linnaemyia Rd. sp................Exudations from tunnel of European corn borer in stalk of sweet corn.

Protacanthus milbertii Macq.........Bumble-bee, *Bombus impatiens* Cress.

        Melon bee, *Melissodes bimaculata* LeP.; stinkbug, *Euchistus variolarius* P. de B.

HEMIPTERA

Euchistus variolarius P. de B.......Sweet corn plants (stalk).

Perillus bioculatus (Fab.)..........Chrysomelid larva, *Lema trilineata* Oliv.

Nabis ferus L...................Plant bug, *Lygus pratensis* L.

HYMENOPTERA

Apis mellifera L..................Tassels and pollen of sweet corn.

Bombus americanorum Fab.........Tassels and pollen of sweet corn.

Bombus auricomus Robt...........Tassels and pollen of sweet corn.

Dinocampus coccinellae Schrank.....Reared from following three adult coccinellidae:
Ceratomegilla fuscilabris Muls.
Hippodamia convergens Guer.
Hippodamia parenthesis Say.

Prenolepis imparis Say...........Larva of European corn borer, *Pyrausta nubilalis* (Hbn.)

Sphex urnarius (Dahl.)...........Lepidopteron larva, *Plusia* sp.

Telenomus podisi Ashm...........Reared from stinkbug eggs, probably *Euchistus variolarius* P. de B.

Zamicrotoridea syrphicola (Ashm.)...Syrphid larva, probably *Bacchus* sp.

LEPIDOPTERA

Acromycta oblinata (S. & A.) (larva). Sweet corn.

Anosia plexippus L. (larva).........Milkweed.

Ceramica picta Harris (larva)......Sweet corn.

Cirphis group. (larva).............Sweet corn.

Diacrisia virginica Fab. (larva).....Sweet corn.

Estigmene acraea Dru. (larva)......Sweet corn.

Geometridae sp. (larva)............Sweet corn.

Heliothis obsoleta Fab. (larva)......Sweet corn, leaves and ears.

Plusia sp. (larva)................Sweet corn.

Prodenia sp. (larva)..............Sweet corn.

Prodenia ornithogalli Gn. (larva)....Sweet corn.

Pyralididae (*Pyraustinae*) sp. (larva).Sweet corn.

Pyrausta nubilalis Hbn. (larva).....Sweet corn, ears and stalks.

Vanessa atlanta L. (adult)..........Fermenting exudations from tunnel of European corn borer larva in stalk of sweet corn.

Vanessa cardui L. (pupa)..........Sweet corn.

NEUROPTERA

Chrysopidae sp. (larva)............Eggs of European corn borer *Pyrausta nubilalis* (Hbn.)

NOTES ON SUBTROPICAL PLANTS AND ANIMALS IN OHIO

CHARLES OTTO MASTERS
Western Reserve University

SUBTROPICAL ALGAE IN OHIO

Throughout the year, the indoor pools of the William Tricker Company in Independence, Ohio, serve as a reliable source of subtropical aquatic plants and animals. Since the greenhouses are devoted to the propagation of waterplants and tropical fish, the water, within, is always kept above seventy degrees Fahrenheit.

Extremely interesting forms come and go but some of those which are not quite so ephemeral remain and can be observed at any time. For the last four years, collections of algae have been made there and we have usually been able to obtain fairly large quantities of a species which up until October, 1938, had been unknown to us.

Dr. Clarence Taft of Ohio State University identified the algae from a sample sent to him as *Compsopogon coeruleus*, one of the rarer members of the family, Rhodophyceae, or red algae. According to Gilbert Smith, the genus is one that has always been considered tropical or subtropical in distribution.

The occurrence of this species in Ohio was undoubtedly due to its introduction along with subtropical aquatics planted in the pools, and it is of especial interest to observe it in other local water gardens and aquaria throughout northern Ohio.

SPREAD OF A FRESH-WATER BRYOZOAN IN NORTH AMERICA

In January, 1934, while collecting brown hydra in the indoor water-lily pools of the William Tricker Company greenhouses the writer observed hundreds of small colonies of fresh-water bryozoa on the leaves of water plants and on the sides of the cement tanks. These were later identified as *Lophopodella carterii* from the article entitled "Studies on Fresh-water Bryozoa. 1. The Occurrence of *Lophopodella carterii* (Hyatt) in North America," by Mary Rogick of Ohio State University, which appeared in the October, 1934, issue of the Transactions of the American Microscopical Society. These first specimens

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described and sent to the United States National Museum by Miss Rogick came from southwestern Lake Erie.

However, in Science (June, 1934), Professor Ulric Dahlgren of Princeton described the form which we suspected as being similar to those appearing in Independence as having been found four years earlier in the Delaware and Raritan Canal at Princeton, New Jersey. In the September, 1934, issue of the Ohio Journal of Science, the results of the collections made by Mary Rogick were published.

Since the bryozoa first appeared in the warm water of the greenhouse pools, they have become extremely abundant there covering many of the submerged flower pots, pipes, plants, and tank walls. Within a very short time, they appeared in the pools of the Buskirk Company of Independence. Later on they were observed growing in aquaria in other parts of northern Ohio.

Concerning the spread of this animal, it is of interest to consider the role played by the William Tricker Company which has imported aquatic plants from many tropical and sub-tropical areas throughout the world, and, in turn, has shipped them throughout the entire country. I have actually seen many plants covered with this beautiful form being sent to water-garden enthusiasts in various sections of the country. Interestingly enough, too, this same company has its main plant, seventeen acres of growing pools and greenhouses, located at Saddle River, New Jersey, the same state in which Dr. Dahlgren first described the bryozoan. As Dr. Dahlgren stated in his article, it is a clean form, and makes an extremely interesting inhabitant of an aquarium.

A New Manual of the Liverworts

For the student beginning the study of liverworts, this manual is the finest thing that has come to the attention of the reviewer. One hundred eleven species in fifty-six genera are described and illustrated. The descriptions are lucid and adequate. The line drawings are well-arranged on twenty-six plates and emphasize essential diagnostic characters. The key to genera and the keys to species are based in large part on vegetative characters enabling one, except in certain cases, to determine sterile specimens. Other interesting and useful features which might be mentioned are a list of abbreviations of names of authors of species and genera; a list of species names and their meanings; a glossary of terms used in the descriptions with references to illustrations on the plates; a bibliography including one hundred ninety-three titles. The book is well bound in cloth and contains remarkably few typographical errors.—*Richard T. Wareham.*

A **Manual of the Liverworts of West Virginia**, by Nelle Ammons. 164 pp. Notre Dame, The University Press. 1940. $1.75.

THREE NEW AUSTRALIAN ENCYRTID GENERA

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The following three genera comprise a part of A Systematic Monograph of the Australian Chalcidoidea, the manuscript of which is now in the archives of the Queensland Museum at Brisbane. The manuscript is foolscap and of over 2,000 pages; and though containing a bibliography has not as yet been indexed. Despite this lack of index, a very necessary and exceedingly useful part, the Monograph contains complete diagnoses of the genera and species of the group, together with many as yet unpublished new descriptive notes, corrections and so forth. It corrects and consolidates all the matter so far published upon and gathered to date, about the group as it occurs upon the continent of Australia (including adjacent coastal islands).

Gounodia new genus.   Ectromatini

Like the genus *Epistenoterys* except that the frons is not prominent, it is wide and the scape is flat but not dilated. Palpi exceptionally for the tribe, 1- and 2-jointed.

Gounodia mellea.   Genotype, new species

Yellow, the legs, the club of the antennae and the basal two-thirds of the ovipositor, pale. Metatarsus exceeding the middle tibial spur but not half the length of its tarsus (leg No. 3). Ovipositor a third the length of the abdomen. Fore wing bearing 7–8 lines of discal cilia proximad of the hairless line. Joints Nos. 1–5 of the funicle a bit wider than long, the pedicel longer, twice longer than widest. The male is described in MS. A male and three females reared from *Sphaerococcus tomentosus*, Perth, West Australia, L. J. Newman.

Bachiana new genus.   Ectromatini

This genus is like the genus *Pseudanusia* except that the first joint of the funicle is ring-like (as in some genera of the Mirini).

Bachiana curiosa.   Genotype, new species

As *Phauloencyrtus mirisimilis* except the mandibles; and the knees, tibial tips, a cinctus upon the long middle femora near the base, are white; ovipositor half the length of the abdomen; scape slender, black,

the joints of the funicle after the first, subquadrate. A male and two females reared from *Mytilaspis cordylinidis*, Perth, West Australia, L. J. Newman.

Compare with the following genotype with which it was for some time confused. The two are remarkable similitudes.

Phauloencyrtus new genus. Mirini.

Like *Pteromalencyrtus* but the mandibles small and acutely 3-dentate, strong, the middle tooth somewhat longest; abdomen short and triangular. Eyes very pilose. Middle tibial spur not elongate, distinctly shorter than joint No. 1 of the second tarsus. In my modernized table, runs next to *Ceraptrocerus*. But the first joint of the funicle is ring-like, the flagellum not flattened.

Phauloencyrtus mirisimilis. Genotype, new species

As *Pteromalencyrtus* genotype but the fore wing dusky at base; there is a line of cilia along the submarginal to base; and the two well-separated lines proximad of the hairless line are joined caudad, running to wing base; vertex with short setae, frons moderate. Spiracle of the abdomen at basal third, the abdomen as long as wide at base. Gordonvale, Queensland.

I ought to state, in this connection, that the Monograph noticed above also contains a complete new classification of the Chalcidoidea based upon Ashmead, a classification of the families and their divisions. Ashmead had long since laid the foundation for the proper classification of this great group but it has been very badly stated and was confused. A reduction of one or two families is indicated. Ashmead was overburdened and did not live long enough to state his views clearly.

The Newest Things in Science

This excellent little volume summarizes the advances in various fields of science for 1939. This alone would make it valuable, but in addition brief histories of the developments leading to each new discovery are given, adding immeasurably to the value of the book. The subjects include plant hormones and other phases of growth, cancer, shock treatment of schizophrenia, sex and sex hormones, television, atom-smashing, chemistry, astronomy, and others. The style is popular and very readable, but nevertheless accurate and not too simplified. The book should be a fine reference work for anyone interested in science.—*L. H. S.*

Science Front, 1939, by F. S. Taylor. 301 pp. New York, the Macmillan Co. 1940. $2.50.

A COMPARISON OF PLANKTON COUNTS FROM THE TRAP-NET AND WATER BOTTLE CENTRIFUGE TECHNIQUES

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INTRODUCTION

Quantitative plankton methods have been the subject of considerable study, but many workers making routine plankton counts have concerned themselves little with problems arising out of certain common techniques.

In a study of collections with the Birge quantitative, closing, plankton tow net (Kraatz, 1931), the writer made counts under binocular in the entire Sedgwick-Rafter counting cell, not only of zooplankton such as Entomostraca and Rotifera, but also of as many others of somewhat smaller size as feasible; and as usual, counted the smaller plankters on microscope (16 mm. objective and 7.5 ocular) with Whipple ocular micrometer in 20 squares, multiplied by 50 to get the cell counts. For plankters counted both ways, where numbers involved were small, the numbers secured by multiplying were almost invariably larger, often much larger than the whole cell counts, which were correct. One can conclude that the larger the portion counted of any kind of plankter in the cell, the more accurate the results.

In the present paper while the same comparison is in the background, the principal comparison is between counts of organisms collected by the trap and the water bottle.

The main objectives of the writer's investigation, the seasonal and other plankton distribution, will be presented in another paper, where also will be given records of temperatures and chemical tests. There also acknowledgments will be made to all those who assisted in the collection and otherwise.

Realizing after studies were made that statistical checks on apparent discrepancies of trap-net and water bottle centrifuge counts would be important, the writer entirely uninformed in such matters, secured the aid of Dr. Wm. E. Ricker, who gave most valuable information in personal communications and in his papers (Ricker 1937, 1937 (a), 1938) to which readers should refer for explanation of statistical methods in plankton work.

COLLECTING METHODS

Collections were made in Turkeyfoot Lake, near Akron, Ohio, from August, 1936, to March, 1939, with unavoidable omission of certain winter months. The Foerst plankton trap, 10 liters capacity, having cone net and bucket of No. 25 silk bolting cloth, as on the Birge net and the Kemmerer-Foerst brass water bottle, 2 liters capacity, both donated by the Ohio Division of Conservation, were used in collecting.

Trap samples, 10 liters, were uniformly concentrated to vial samples of not quite 40 c. c. Water bottle samples were uniformly one liter; the other liter was used for chemical tests. The one liter used was thoroughly representative of the two liters collected.

DISCUSSION OF COLLECTING METHODS

The trap-net is better than the net alone, in that it obviously collects a known quantity of water, but is subject to the same losses of small organisms through meshes of the concentrating net. The net used was old and had previously shrunk, (as new cloth will shrink in water) and the meshes were to some extent clogged.

Most water bottle plankton collections have been one or two liter samples. It is impracticable to carry a set of bulky ten liter or even five liter sample bottles. Larger samples would give theoretically better representation of lake population, a point considered negligible by many workers, especially when they count only the smallest plankton from the water bottle.

LABORATORY METHODS

Preservation of trap samples was accomplished at once by having about one c. c. of formaldehyde in the vial when collection was made. In the laboratory a little distilled water was added to make each trap sample exactly 40 c. c. later as the sample was to be examined. After thorough agitation one c. c. was put in the Sedgwick-Rafter counting cell.

The one liter water bottle samples were not preserved initially, but immediately after return to the laboratory they were centrifuged, each in about 7 minutes for one centrifuging, as advised by Foerst, and by Juday. The Foerst electrically run water centrifuge has an r. p. m. of 15,000. The plan of two centrifugings for each sample was adopted. Distilled water was added to the residue to wash it out of the cup of the centrifuge. Later for examination the samples were uniformly made up to 20 c. c.

In a great deal of other plankton work, counting cell samples from the trap-net were examined for so-called net plankton and from water bottle, for the so-called nannoplankton or dwarf plankton. In recent Ohio Conservation Division work trap samples were examined for zooplankton and water bottle samples for phytoplankton, which is efficient from the standpoint of two observers working with the separate samples and makes for a biological division of groups desired.

The writer decided to examine trap samples for all plankton and water bottle samples likewise, to secure a check if possible, comparing the two collecting and concentrating techniques. For both, the one

c. c. in the counting cell on low power binocular, × 48, with aid of mechanical stage, was counted completely for Entomostraca, Rotifera and also others like Ceratium, when feasible, and then the smaller more abundant forms were counted in 20 squares of the Whipple ocular micrometer, on the microscope with 16 mm. objective and 7.5 ocular. Therefore, a comparison of samples from trap and water bottle could be made.

Due to the particular size of the samples, the trapnet count, when of the whole cell as for larger plankters, represented ¼ of a liter, but when counted in 20 squares (multiplied by 50 to get the total) the actual count was of 1-200 of a liter. For the water bottle the two counts represented 1-20 of a liter and 1-1000 of a liter respectively.

DISCUSSION OF PLANKTER SIZE IN RELATION TO COLLECTION AND CONCENTRATION METHOD

It has long been recognized that even the finest mesh tow nets allow the smallest plankton organisms to escape and that if the plankters are very slender long colonies or individuals, they might be retained in variable degree, but could if exactly endwise pass through the net meshes. The organisms too small to be collected by net, the nannoplankton, are collected by water bottle.

But to count zooplankton only from trap samples and phytoplankton only from water bottle centrifuged samples, seems arbitrary, especially since many Protozoa would belong to nannoplankton, and on the other hand, many plant colonial types, larger Cyanophyceae and Chlorophyceae and some diatoms are net plankton.

A separation of net plankton and nannoplankton on basis of size is essential, but it does not seem feasible to maintain exact size difference as indicated by Welch (1935, p. 208). A separation on basis of kinds, species or genera, though not necessarily accurate, seems practicable.

In most routine work genera alone can be listed. It is notable that Birge and Juday (1920, p. 60) list in net plankton, besides Entomostraca and Rotifera, the following: Ceratium, Microcystis, Coelosphaerium, Aphanizomenon, Anabaena, Lyngbya, Staurastrum, Melosira, Tabellaria, Fragilaria, Asterionella, Stephanodiscus, but again among nannoplankton, p. 90, list Coelosphaerium, Stephanodiscus, fragments of Aphanizomenon, but also thirteen other genera of algae and Rhizopoda and Ciliates.

Turkeyfoot plankton includes prominently a large type of Coelosphaerium, large Anabaena, and also considerable Microcystis and abundant Aphanizomenon. The latter is a more slender filament than the Anabaena. All these, and also the diatoms Asterionella, Synedra, of large size, and Fragilaria, occurred prominently in trap-net samples showing very typical development and decline periods during a year. However, certain comparisons of net and centrifuged samples will be made later.

In contrast to the above which can be termed net plankton, there were found at certain times a very much smaller kind of Synedra, a very tiny filament identified as a small Oscillatoria, a smaller type of Coelosphaerium, Trachelomonas, and in just two collections one fall

a tiny diatom Amphora. Practically none of these were revealed in trap-net samples. They occurred in centrifuged samples, and whenever they did, especially the tiny Synedra, and Oscillatoria and Amphora, in enormous numbers.

But nannoplankton have not been revealed adequately in this study, despite water bottle collections, due to limitation of practicable magnifications. The Sedgwick-Rafter counting cell and Whipple micrometer permit only work with 16 mm. objective and 7.5 ocular. For identification occasionally a 12.5 ocular was substituted, but all counts made with 7.5 ocular. No examination was made of a drop mount under thin cover glass and high powers. Dr. C. E. Taft identified many smaller algae and Dr. L. E. Noland some small Protozoa. Dr. Noland pointed out the difficulty of identification of preserved ciliates and others. While these types were numerous, most did not occur in great numbers relatively and it was found impossible to consider and count them in the routine work. The total quantity of nannoplankton, however, would be enormous.

The nannoplankton can be omitted from this paper as the comparisons are essentially of net plankton, as revealed in the two different collecting and concentrating techniques.

LOSSES IN CENTRIFUGING

The centrifuging process tended to break up some larger filamentous colonies, especially Anabaena, making it harder to count the colonies. Asterionella maintained its star-shaped arrangement remarkably well, except in a few instances. A few others were sometimes broken, most surprisingly the hard-shelled Ceratium. Sometimes its points were broken; sometimes it was broken in two across at the groove.

A worse feature was the loss of some blue-green algae over the top of the small inside cup of the centrifuge so that they went with the overflow water instead of the sample. The large Coelosphaerium and the Anabaena were lost in large degree, Microcystis to nearly the same extent, Aphanocapsa, somewhat less and Aphanizomenon usually was not lost. This will be again brought out in the tables. Dr. Juday wrote me that he had little trouble of this sort in his long experience, except with Aphanizomenon.

The centrifuge was working well. A stroboscope test on the empty centrifuge showed not far below 15,000 r. p. m.

Coelosphaerium and Anabaena are low in specific gravity, especially when more or less in condition of water bloom, but less so in colder weather when numbers are low. They tend to gather in the top layer of water. In one case a liter bottle purposely left standing for some time before centrifuging, showed a thin line of these gathering on the water surface. In the case of the net condensed vial samples, a dense layer of from one to two mm. thick would form on the top of the four-inch column in the vial. At the same time other plankton tended to sink to the bottom. Even in counting cell samples, in a very short time after making the cell mount, these same blue-greens would tend to come up to the cover glass. To be sure, the net samples in the vials and all samples on the microscope were preserved, but the preservative

was a slight amount compared to the water volume. And it must be repeated that material in samples at centrifuging was alive.

Every sample was centrifuged twice. Nevertheless, as shown in the tables, nearly all these blue-greens were lost in centrifuging. More centrifuging was not feasible in routine work. But a test case was made in which one liter was centrifuged five times. Lengthy examination showed ample Coelosphaerium and Anabaena in overflow water, but none in the sample after the first centrifuging. Again in each of the subsequent centrifugings of the same overflow water, large but decreasing numbers were indicated in the overflow water, and but slight increases in the successive samples, but a fair improvement in the last. It is surprising that there should not have been more improvement, especially since all other organisms were successfully removed the first time. A trap-net sample taken at the same time and place as the above centrifuged sample, proved a rich supply of these blue-greens present.

REPRESENTATIVE PLANKTON COMPARISONS

DISCUSSION OF TABLES

In the tables the most direct comparison is between counts of plankton collected by trap and collected by water bottle, the method of concentration being by net as compared with centrifuge, indicated by "net" and "centr." respectively.

TABLE I

CYANOPHYCEAE

Numbers in 1 Liter of Turkeyfoot Lake Water, June 19, 1937

ORGANISMS	SURFACE WATER		4 METERS		8 METERS		12 METERS	
	Net	Centr.	Net	Centr.	Net	Centr.	Net	Centr.
Coelosphaerium	4,100	460	5,200	1,320	1,400	180	896	1,520
Aphanocapsa								
Microcystis	800		600	380	400	60	236	140
Oscillatoria								
Anabaena	8,000		6,800		1,400		1,272	
Aphanizomenon	153,600	337,000	183,200	391,000	25,200	8,000	37,000	150,000

Tables II and III. All main groups, represented by the chief plankton organisms found more or less throughout the collecting period, are included. Of these the green algae were least common. Many other kinds were found from time to time. All types included are net plankton, though some are not so perfectly collected by net.

Certain nannoplankton were counted, but as previously explained, they are omitted as being outside the scope of this paper.

Cyanophyceae.—Tables I, II and III. A glaring lack in centrifuged samples (as described above) of Coelosphaerium, Anabaena, and the less common Microcystis is seen. This applies less fully to the Aphanocapsa.

TABLE II

CYANOPHYCEAE AND OTHERS

Numbers in 1 Liter of Turkeyfoot Lake Water, July 19, 1937

ORGANISMS	SURFACE WATER		4 METERS		8 METERS		12 METERS	
	Net	Centr.	Net	Centr.	Net	Centr.	Net	Centr.
Coleosphaerium	4,000		4,400	1,450	2,200		4,400	75
Aphanocapsa	1,400		1,200		200		1,200	
Microcystis	3,600		2,400	1,250	1,400		2,400	
Oscillatoria				1,250			200	
Anabaena	65,600	5,000	49,607	7,500	10,400		42,800	
Aphanizomenon	18,400	232,000	34,400	46,250	4,800	2,500	20,400	
Melosira	1,000	3,000	800	1,250	1,800	5,000		1,250
Synedra								
Asterionella								
Fragilaria	800	3,000	600	5,000			200	1,250
Stephanodiscus	1,200	1,000	1,000		2,400		3,000	
Staurastrum	36		40	150	80		100	
Pediastrum	20	40				75	24	
Ceratium	4,940	760	2,964	175	644	150	656	50
Polyarthra	492	540	144	150	12			
Keratella	324	460	656	425	192	325		
Synchaeta								
Asplanchna								
Notholca	92	100	12	75	8	75		
Nauplius	108		96	50	60		96	25
Cyclops			24	25	12		8	
Diaptomus			8		4		4	
Daphnia	12	20	8	25			4	
Bosmina								

However, the very abundant Aphanizomenon is frequently well centrifuged. Table I shows twice as much in centrifuged surface and 4 meter samples as in trap-net samples, but an inconsistency at 8 meters and again a relatively very high count at 12 meters. Table II shows the same situation, but with a peculiar total absence of centrifuged spec-

imens at 12 meters.   One might on the whole conclude that centrifuging was definitely the better method and that the net lost many.   But Table III shows no such discrepancy between the two concentration methods.

TABLE III

Cyanophyceae and Others

Numbers in 1 Liter of Turkeyfoot Lake Water, June 18, 1938

Organisms	Surface Water		4 Meters		8 Meters		12 Meters	
	Net	Centr.	Net	Centr.	Net	Centr.	Net	Centr.
Coelosphaerium	400		1,000		400		150	
Aphanocapsa								
Microcystis								
Oscillatoria								
Anabaena	10,600	1,000	9,800	1,000	9,800		800	
Aphanizomenon	9,600	6,000	8,600	8,000	5,400		200	
Melosira								
Synedra								
Asterionella			200		600	21,000	7,200	30,000
Fragilaria	600		200		200			
Stephanodiscus								
Staurastrum								
Pediastrum	800	60	48		28	80	32	
Ceratium	24,800	26,000	16,400	20,000	22,240	19,000	3,744	2,000
Polyarthra	156	20	156	60	296	100	124	
Keratella	36	40	20		48	40	36	
Synchaeta								
Asplanchna	16		24		12			
Notholca								
Nauplius			52	80	52	100	36	20
Cyclops			8	20	16		4	20
Diaptomus			24	20	48	60	8	
Daphnia	4		16		52		4	
Bosmina					4			

Statistically considered, the discrepancies of various sizes can be evaluated.   Following methods elucidated by Ricker (1937, p. 74) and furthermore applied by him to certain of my examples in personal letter, a simple illustration can be given of Anabaena and Aphanizomenon in Table III.

The members per liter for the four depths can be added. This tabulation follows:

	Per Liter	Actual Count	Limits of Confidence	Confidence Limits per Liter of Lake Water
Net	30,100	155	132 to 181	26,400 to 36,200
Centr.	2,000	2	0.2 to 7.2	200 to 7,200

In the possible statistical ranges there is no overlapping whatsoever for the two methods. In other words, these discrepancies are proven significant, and it is positive that the centrifuged samples are of no value in the case of Anabaena. In the case of Coelosphaerium the same thing would be demonstrated. In corroboration was the evidence described previously of the losses in actual centrifuging.

But in Aphanizomenon, the picture is different.

	Per Liter	Actual Count	Limits of Confidence	Confidence Limits per Liter of Lake Water
Net	23,800	119	99 to 142	19,800 to 28,400
Centr.	14,000	14	7.7 to 23.5	7,700 to 23,500

These differences are not actually significant, because of over-lapping of the statistical ranges secured from the two concentration methods.

To be sure, if Aphanizomenon counts of Tables I and II were taken as examples and similarly worked out, we would find in the statistical ranges of limits of confidence per liter of lake water of the two techniques, a real significant difference, but the centrifuge is higher.

Conclusions regarding Aphanizomenon are consequently difficult to make. Sometimes some seem to be lost in centrifuging, though generally not, and some may pass through the net, depending possibly upon massing of the filaments, if more isolated, passing through more freely.

The other plankton organisms of Tables II and III can be quickly compared. These and a score of others of the same station show innumerable small differences in counts calculated to numbers in one liter when net and centrifuge results are compared. The many differences found were disconcerting during this study, but statistical analysis will show most of them of little significance.

Diatoms when very abundant as in the normal spring maximum offer another problem. Tables IV and V demonstrate that while the net collection numbers are large and seem to show successful collection, with huge numbers and normal rises and declines in various parts of the year, the centrifuge numbers are, though practically only at the height of the season, still far greater than the net totals. At the maximum, a significant difference is proven, as in Asterionella, 1937, (Table IV) and Synedra, which, however, never attains the numbers of Asterionella at its maximum. In 1938 (Table V) Synedra reveals the same picture and even greater numbers, but Asterionella is relatively low

compared with a year before, and oddly the discrepancy between net and centrifuge counts is not so pronounced. But one month later, May, 1938, Asterionella reached a maximum though not duplicating that of April, 1937, but with the same discrepancies between net and centrifuge. Possibly when the numbers become enormous, more are pushed through the net meshes.

TABLE IV

DIATOMS

Numbers in 1 Liter of Turkeyfoot Lake Water, April 24, 1937

ORGANISMS	SURFACE WATER		4 METERS		8 METERS		12 METERS	
	Net	Centr.	Net	Centr.	Net	Centr.	Net	Centr.
Melosira	150			1,000	600			1,000
Synedra	7,650	21,000	4,400	27,000	3,000	18,000	2,600	31,000
Asterionella	140,100	856,000	136,200	1,139,000	126,000	955,000	94,400	811,000
Fragilaria	1,050	3,000	600	5,000	1,000	6,000	1,400	4,000
Stephanodiscus	600	2,500	300					3,000

TABLE V

DIATOMS

Numbers in 1 Liter of Turkeyfoot Lake Water, April 16, 1938

ORGANISMS	SURFACE WATER		4 METERS		8 METERS		12 METERS	
	Net	Centr.	Net	Centr.	Net	Centr.	Net	Centr.
Melosira	1,000		1,200		1,200	1,000	2,000	1,000
Synedra	45,000	64,000	50,200	76,000	55,000	224,000	40,600	178,000
Asterionella	18,200	12,000	26,000	13,000	15,400	19,000	19,000	3,000
Fragilaria	200	1,000	800	1,000	24		200	1,000
Stephanodiscus								

Entomostraca, being relatively gigantic plankton and also rotifers, are not present in such great absolute numbers, but do show normally large populations. There are no very significant differences between net and centrifuged records, though in some cases Entomostraca are missing in counts of centrifuge sample when present in small numbers in net samples, showing that the 1 liter water bottle sample is rather too small.

On the other hand, sometimes the centrifuge number, a round number, appears larger. This does not indicate that the centrifuge collection is better. Indeed it is less accurate than the net collection because based on fewer actual counted specimens and involving more

multiplication in the calculation. For example, (Table III) Nauplius at 8 meters has 82 in net sample and 100 in centrifuge sample. Actually, 13 were counted in the one c. c. from the 40 c. c. net sample; multiplied by four, showed 82 in a liter. But only 5 were actually counted in the one c. c. of the 20 c. c. centrifuge sample; multiplied by 20, would show 100 in a liter. The 100 is less accurate and probably a little too large.

Similarly in counts of smaller organisms when counted in 20 squares, when still more multiplication is necessary. For example, Fragilaria in Table II, at surface shows 800 in net and 3000 in centrifuge samples. Naturally, there is no proof in this case that some might not have gone through the net. In net sample 4 were counted in 20 fields; $4 \times 50 \times 4$ yields 800, the liter number. In the centrifuge sample 3 were counted in 20 fields; $3 \times 50 \times 20$ yields 3000, the liter number. In various scattered cases occur instances of appearance of 1000 supposed individuals per liter in centrifuge samples, in each case based on only one actually counted in the 20 squares of the cell. Invariably in those cases, the number 1000 is larger than the calculated number in net sample. Mostly the differences are small and not statistically significant. Nevertheless, it is more than a coincidence that such centrifuge numbers are larger than the respective net numbers. They are somewhat less accurate.

In plankton work, samples at least several times larger than one liter are advantageous, because in the small residual samples counted, there will be represented a larger liter fraction that is actually counted. Naturally the counting cell sample must not be too concentrated for accurate counting. Between any two samples secured by 2 collecting techniques, that sample is better which has a larger volume of its water surveyed and more of its plankters counted, and which requires the least multiplying to get the number per liter.

This is important, but it is not an indictment of the water bottle as such, but of the relatively small size bottle ordinarily used, as compared with the trap.

SUMMARY AND CONCLUSIONS

Plankton collections made with trap and with water bottle have ordinarily been handled as two separate entities with mutually exclusive groups of organisms counted from each.

In this study all plankton (except some obvious nannoplankton) was studied and compared throughout from trap and water bottle samples.

The comparison served as a check of the two methods, theoretically valid throughout the range of net-plankton.

Some organisms are difficult to classify into net plankton or nannoplankton.

The net (as is well known) allows real nannoplankton to pass through its meshes.

The water bottle (as is well known) retains all nanno-plankton.

Many small differences occur between samples concentrated by the net and by the centrifuge, though most of these are not statistically significant.

Water bottle samples as made in this study and frequently otherwise, are too small in quantity compared with the 10 liter trap samples. If the bottle samples were larger there would be more and more offset to the disadvantage next listed.

The larger the portion of any collected sample which has its plankton actually counted and the less multiplication required to secure numbers per liter, the better the results. In that sense the trap-net samples are better than the centrifuge samples when done in the manner described.

The centrifuging process at 15,000 r. p. m. introduces some problems, in breaking up some organisms, thus adding to inaccuracy of counts, and moreover in failing to retain in the centrifuged sample, many important blue-green algae of low specific gravity, especially of the summer collections.

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So You Plan To Write a Book

This compact little guide is one of the most valuable books that has fallen to my lot to review in many a month. It is an informal but straight-from-the-shoulder discussion of the provinces, properties and responsibilities of authors, publishers and printers. From the would-be author to the seasoned veteran and the experienced editor, those who have to do with writing for publication will derive untold benefit from a careful study of its pages. Yet "study" is hardly the word, for not only is the book crammed with meat, but it is so delightfully written that the conclusion is almost inescapable that Mr. Gill missed his calling in being a publisher: he should have been an author.—*L. H. S.*

The Author Publisher Printer Complex, by Robert S. Gill. iv+76 pp. Baltimore, the Williams and Wilkins Co., 1940. $1.00.

Zoology of the Invertebrates

The introductory volume of the first American treatise on invertebrate zoology has just appeared. Doctor Hyman has proposed to write a series of several volumes and the first one is concerned with Protozoa, Mesozoa, Porifera, Cnidaria, and Ctenophora. Hyman's treatise is unusual, when compared to other works of its range, in that it is being written by one individual. The author has relied heavily on the literature and in this connection it is gratifying to see that the literature of all countries has been consulted with care and recent reports are represented. However, she herself has published well known researches on two of the phyla and has made original observations on two others and writes, therefore, with the experience of first-hand information. The large variety of species considered in detail (the "type" method is not used) covers the variations within each phylum and necessitates a well planned presentation of the numerous facts so as to avoid confusion and repetition. The morphological phase of zoology is particularly evident in more than 1,600 good illustrations, and animals as organized living units are well represented by abundant information on their embryology, physiology, ecology, and life histories. An excellent index enables one to locate subjects readily. There are three chapters, in addition to the five which treat the phyla named above, which deal with Protoplasm, the Cell, and the Organism; Classification; and Introduction to the Lower Metazoa. These chapters are valuable in abundance of factual material. Throughout her book and especially here, the author thoroughly discusses and carefully evaluates zoological theories, many of which have become confused with facts. The precise style of writing, freshness and completeness of material, and logical handling of doubtful and theoretical topics, all indicate that the volume will serve admirably for a textbook and for reference. It is not hazardous to predict that the usefulness of this book will be enormous.—*Carl Venard.*

The Invertebrates—Protozoa through Ctenophora, by Libbie Henrietta Hyman. ix+726 pp. 221 figs. New York, the McGraw-Hill Book Co., Inc., 1940. $5.50.

Van Nostrand's Scientific Encyclopedia

This comprehensive compilation of scientific information has as its objective the coverage of fundamental and technical principles in the following twelve fields: Chemistry, Physics, Mathematics, Engineering, Astronomy, Medicine, Mineralogy, Aeronautics, Navigation, Geology, Zoology and Botany. It is clearly and concisely written. The subject matter included shows evidence of having been carefully selected and is well illustrated by a large number of diagrams and photographs. By way of less favorable criticism it seems unfortunate that in the table on page 242 the molecular volume is given as 22.2 liters whereas the generally accepted value is 22.4 liters; also on page 1090 the use of the admittedly imperfect analogy of an inflated rubber balloon in the discussion of Surface Tension might well be omitted in the interest of clarity and accuracy. On pages 452-3 under Feedwater Treatment the technical water items are good but suffer somewhat by the absence of a discussion of the modern anion exchange reactions. In this section near the bottom of page 453 the statement, "Foaming results also from the saponification of the boiler water . . .", makes a rather curious use of the phrase "saponification of water," inasmuch as water is not saponified. Further, on page 1127 under the discussion of "Three-Phase Equilibrium" . . . (See *Siblimation*) . . ." should read *Sublimation.* Generally, however, as one uses this Encyclopedia he is favorably impressed by its relative freedom from error and by its up-to-date character. It will undoubtedly find its greatest value, not as a supplementary source of information for the specialist in a given field, but rather as a ready and convenient reference for him in other and less familiar fields. The book is attractively and durably bound, printed clearly on good stock and should stand up well under a great deal of use. The authors of this work have accomplished their main objectives in a very satisfactory manner and the book should prove to be a valuable addition to scientific literature.—*Wesley G. France.*

Van Nostrand's Scientific Encyclopedia. 1234 pp. New York, D. Van Nostrand Company, Inc. 1938. $10.00.

AN ECOLOGICAL EFFECT OF THE NEW ENGLAND HURRICANE

MARY D. ROGICK

College of New Rochelle

On September 21, 1938, a hurricane and an unusually high tidewater struck the general region of Woods Hole, Mass.[1] In addition to destruction of life and property, disruption of transportation and communication, etc., there was a distinct effect on the ecology of the region. Frequently during the summer of 1939 there was brought to the attention of the
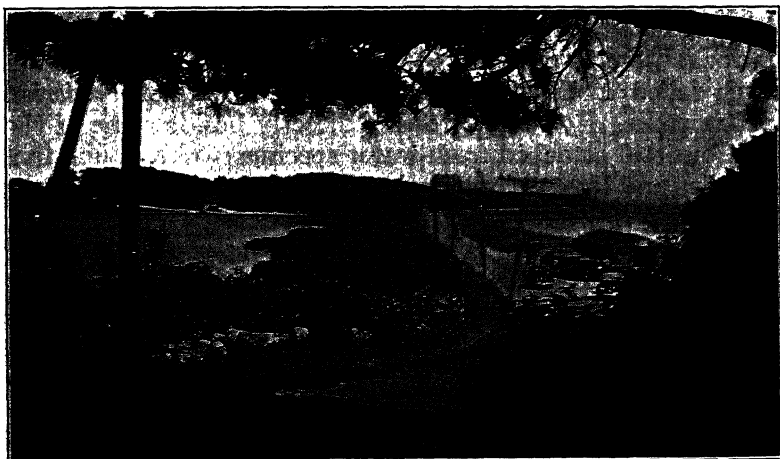
Text Fig. 1. View looking toward the Nobska Light House (center) at Woods Hole, Mass. A road and a few yards of shore separate the Fresh Water Pond (on the left) from the sea (at right). The bathhouse shown at the extreme right next to the cars was washed into the Fresh Water Pond across the road during the hurricane.

students at the Marine Biological Laboratory the fact that the collecting sites showed some changes regarding the quantity and kinds of organisms available, as compared with collections made during the summers of previous years, before the hurricane. Moreover, some of the fresh-water ponds which were in the low lands near the seacoast became salty or brackish because they were flooded with sea water during the hurricane.

The present article deals with such a pond which temporarily at least is brackish. It is known as the Fresh Water Pond and is located in Woods Hole just northwest of the Nobska Light House. This pond is on low terrain only a few yards away from the sea (Text fig. 1). Its bottom is somewhat variable, being of a sandy, rocky and muddy nature, depending upon the part of the pond examined.

Collections of specimens, particularly of Bryozoa or moss animals, were made in the pond several times during the summers of 1938 and 1939. During the summer of 1938, before the hurricane, fresh-water Bryozoa *Fredericella sultana* and *Plumatella* sp. were found growing quite abundantly on the lower surfaces of submerged rocks. When collecting during the summer of 1939, i. e., after the hurricane, the writer was struck with the fact that all fresh-water Bryozoan colonies found on the rocks were the previous year's growth and dead. Diligent search failed to disclose a single living colony of *Fredericella* or *Plumatella*. However, growing directly beside some of these killed but still attached fresh-water specimens were found living barnacles and live, thriving colonies of a salt or brackish water Bryozoan *Membranipora lacroixii*.

The outer chitinous covering or ectocyst of the *Fredericella* and *Plumatella* colonies which remained after the softer parts of the animals had disintegrated was quite sturdy and well cemented to the substratum (Plate I, fig. 5). It was in a good state of preservation. The seed-like reproductive bodies called statoblasts which characterize most of the fresh-water Bryozoa were firmly attached either to rocks or inside the zooecial tubes. A large percentage of the statoblasts were normal in shape or size but several somewhat atypical ones were found and are here figured (Figs. 2, 3, 4). That there is considerable variation in statoblasts is well known to all who have had the pleasure of working with this group.

The salt water species found in the pond the summer after the hurricane was somewhat difficult to name because its synonymy is in a considerable state of confusion. However, Dr. R. C. Osburn in 1910 reported the occurrence of *Membranipora lacroixii* from Buzzards Bay. Since the present pond specimens seem identical with his *M. lacroixii* figures (1910, U. S. Bur. Fish., Bull. XXX, Pl. 22, fig. 28) his terminology is being followed. This Bryozoan forms a delicate white calcareous meshwork or tracery on rocks. The extent of the colony is

varied, depending partly upon age. The largest colony observed was approximately 7 centimeters in diameter. It was collected on September 3, 1939. One rather unusual feature about this colony was that it was growing over fragments of the previous year's *Fredericella* and *Plumatella* colonies which were still attached to the rock.

The smoothness of the substratum on which the colony grows influences to some extent the shape of the zooecia or "cases" in which the individuals are housed. Zooecia growing on a fairly smooth or flattened surface are shaped like those pictured in Figure 9, being quite regular and longer than wide, while those growing over crevices or irregularities may be irregular, pyriform or long and very narrow. The following zooecial and opesial measurements were made on 14 regular zooecia, while the operculum measurements were made on only 4 specimens.

TABLE I

	Maximum in mm.	Minimum in mm.	Average in mm.
Zooecial length..........................	0.52	0.42	0.476
" width..........................	.31	.26	.291
Opesial length..........................	.46	.34	.413
" width..........................	.26	.20	.226
Operculum length.......................	.11	.10	.103
" width.......................	.13	.09	.111

Ovicells and avicularia are lacking. The oral arch is slightly raised and is higher than the rest of the zooecium. Opesia large and elliptical bordered by a narrow, raised, granulate or finely tuberculate rim, some of the delicate processes of which project into the opesia. Several multiporous rosette plates, generally 3 but occasionally as many as 6, may be found in the lateral wall (Figs. 6, 8). The operculum is slightly wider than long, with a chitinous rim reinforcing its edge. The rim is about 15 to 25 micra wide. The operculum is not calcified.

It would be an interesting problem to watch the pond for the reappearance of the fresh-water forms *Fredericella* and *Plumatella* and for the disappearance of the brackish *Membraniporan* species and for succession of organisms over a period of several years.

EXPLANATION OF PLATE I

Figs. 1, 2, 3 and 4. Variously shaped statoblasts (reproductive bodies) of the fresh-water form *Fredericella sultana*. The last three are quite atypical.

Fig. 5. A fragment of a 1938 *Fredericella* colony (dead) collected in late summer of 1939 and showing several empty zooecial tubes (*Z*).

Fig. 6. Fragment of 2 zooecia of *Membranipora lacroixii* (brackish or salt water form) showing 4 rosette-plates (*R*) in the lateral walls (*L*) and a thinner section (*Y*) of the dorsal wall which was observed more clearly on one specimen than on any others. *OE* refers to the large opening or opesium. Part of the lateral wall and opesial border are torn away in this specimen.

Fig. 7. Part of a zooecium of *M. lacroixii* showing the operculum (*O*) which has a distinct chitinous border (*K*). The zooecium is slightly different in shape from those in Fig. 9, but is not at all unusual. Individuals with 2 spine-like processes (*I*) near the oral arch (*OA*) were very rare, occurring only in a few zooecia of a young colony. Some of these processes were jagged and less like hooks than in present figure. *U* refers to the delicate processes projecting into the opesium from the calcareous wall.

Fig. 8. Section of a lateral wall (*L*) of *M. lacroixii* showing a rosette-plate or pore-plate in greater detail than in Fig. 6.

Fig. 9. Section of a colony of *M. lacroixii* showing a number of ordinary zooecia (*Z*) and a rudimentary one. The opercula and membranes covering the zooecial openings have been burned off to show the zooecial outlines more clearly. Abbreviations same as for preceding figures.

Fig. 10. All the preceding figures were drawn with the aid of a camera lucida. The scales for the various figures are here given: Scale *A* for Figs. 1 to 4, *B* for Fig. 6, *C* for Fig. 7, *D* for Fig. 8 and *E* for Fig. 9.

1

2

3

4

OE

Y

L

R

OA   I

O

K

U

Z

6

7

5

U   OE   Z

8

L

R

O   .1   .2 mm.

A

O   .1   .2 mm.

B

O   .1   .2 mm.

C

O   .05 mm.

D

O .1 .2 .3 .4 mm.

E   10

9
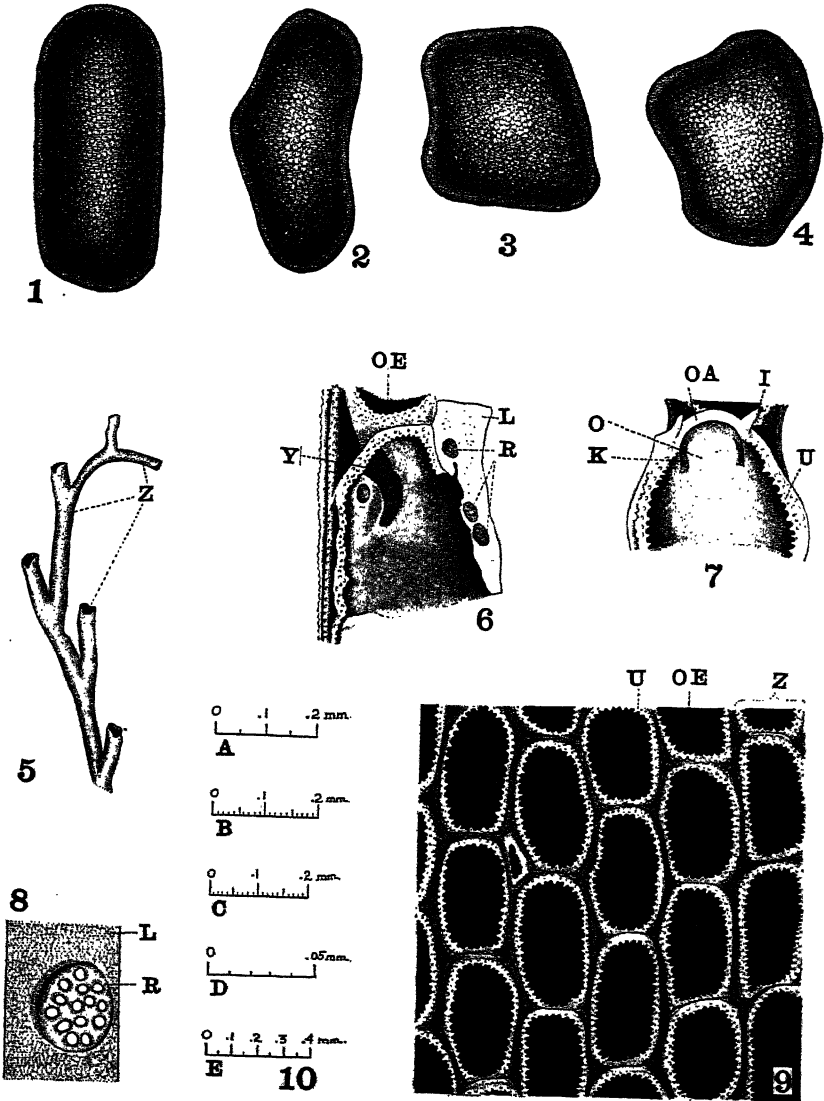
BOOK NOTICES

Pedigrees and Checkerboards

This manual contains more than 100 pedigree charts of various animals and plants, in which the genotypes are to be filled in as far as possible from the phenotypes of the various related individuals. It also includes nearly a hundred problems involving checkerboards. The plants and animals represent diverse species both of the laboratory and of the farm and home. The types of inheritance involved are widely representative, including unit factors, epistasis, sex-linked and sex-influenced factors, multiple alleles, linkage, and chromosomal aberrations. In the plant material nothing is said of xenia, and the endosperm and aleurone are treated as though they contained factors in pairs. As long as all the genes used manifest xenia, this omission of course makes no practical difference in the results of the problems. The distinction between sex-influenced and sex-limited behavior is not drawn. The problems are well chosen, and should be of very practical value to the beginning genetics student.—*L. H. S.*

Pedigrees and Checkerboards, by E. F. Barrows. 223 pp., planographed. Ann Arbor, Edwards Bros. 1940. $1.50.

Physiology and Disease

The first edition of this very comprehensive treatise on medical physiology was reviewed in the Ohio Journal of Science for September, 1937. The fact that a second edition has appeared in only two years testifies both to the importance of the subject and to the success of the first edition. In addition to the many revisions in the text, a section has been added on special senses. This section comprises eight chapters, totaling nearly two hundred pages. The book admirably serves its purpose of bringing the principles of physiology into intimate contact with practical clinical problems.—*L. H. S.*

Physiological Basis of Medical Practice, by C. H. Best and N. B. Taylor. xvi+1872 pp. Baltimore, the Williams and Wilkins Co. 1939.

Exercises in Biology

Although the textbook, *Fundamentals of Biology,* may be used with profit in a non-laboratory course, Professor Haupt has prepared a manual of laboratory directions designed to accompany the material in his textbook. This manual, in the reviewer's opinion, does not attain the degree of excellence achieved in his textbook. The manual presents brief directions for 100 exercises. Since each is designed to be completed within a two-hour laboratory period, of necessity they must be sketchy. Where space is limited and large groups of students must be cared for this manual should prove satisfactory.—*Paul E. Schaefer.*

Laboratory Directions for General Biology, by Arthur W. Haupt. Third edition, 65 pp. New York, The McGraw-Hill Book Co. 1940. $1.00.

The Fundamentals of Life

The great expansion and compartmentalization of scientific knowledge is raising more problems and increasing the difficulty of solution for the teacher of the general courses in the physical and biological sciences. The development of the "principles" method of organization has seemed a step towards a solution, but what shall a text for such a course be and where can it be found? Since no one specific pattern can cover all "principles" courses certainly no one specific pattern can be laid down for such textbooks. Several books have appeared which seem to achieve some measure of success in aiding the student to orient himself with respect to the scope of biological science, its influence upon his life and its role in society.

Amongst those texts which seem usable for such a course, Haupt's Fundamentals of Biology certainly should have a place. In this third edition, although a botanist primarily, Professor Haupt has not slighted the animals but has achieved a rather comprehensive picture of biology without blatant sketchiness. There is a unity of organization which yet permits a degree of flexibility. The language is quite readable, and the general mechanics of the book very satisfactory. This book doubtless will not please everyone, for what book could, but many should find it exceedingly usable.—*Paul E. Schaefer*.

Fundamentals of Biology, by Arthur W. Haupt. Third edition, 443 pages. New York, The McGraw-Hill Book Co. 1940. $3.00.

Cosmic Rays and Mesotrons

This small paper-bound book is written from a research point of view and will be welcomed by graduate students who want a fundamental understanding of experimental cosmic-ray phenomena and their interpretations. The interpretations, however, do not extend to the questionable origin of cosmic rays.

A short chapter is devoted to experimental apparatus such as ionization chambers, Geiger-Müller counters, and Wilson cloud chambers. With these instruments data are obtained on the variation of cosmic-ray intensities with time and latitude, on the absorption of the rays in matter at high and low altitude, and on the penetration of cosmic rays to great depths. The most penetrating component of cosmic rays leads to the concept of mesotrons. The mesotron seems to be between 100 and 200 times as heavy as the electron. There is evidence that the average life of a mesotron is about one-millionth of a second.

In the chapter devoted to the application of the theory of electrons to cosmic rays, the subjects of ionization by collision, showers, and the production of secondaries in the upper atmosphere are effectively treated.

The ten tables and sixteen figures amply illustrate the text and help to make this book a very desirable one in the field of cosmic rays.—*M. L. Pool*.

Cosmic Rays and Mesotrons, by H. J. J. Braddick. 68 pp. Cambridge, at the University Press; in New York, the Macmillan Co. 1939. $1.50.

NOTICE

Copies of the *Ohio Journal of Science*, volume XLV, numbers 1 and 2, January and March, 1940, are needed for sending to the many new members of the Ohio Academy of Science. Those who have copies which they do not care to keep are asked to post them to the Botany and Zoology Library, Ohio State University, Columbus, Ohio.

THE FULL PROCEEDINGS OF
THE FIFTIETH ANNIVERSARY
MEETING, INCLUDING THE INVI-
TATIONAL ADDRESSES, WILL BE
PUBLISHED IN A LATER ISSUE.

ANNUAL REPORT

OF THE

OHIO ACADEMY OF SCIENCE

Fiftieth Meeting

1940

THE OHIO ACADEMY OF SCIENCE

Organized 1891   Incorporated 1892

Affiliated with the American Association for the Advancement of Science

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REPORT OF THE FIFTIETH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

In line with a resolution and plan adopted by the Academy at its annual meeting in 1937 (the 47th), the meeting in 1940 was devoted almost exclusively to the celebration of the "Golden Anniversary." This anniversary was held on May 9, 10 and 11, at Ohio State University and was generally conceded to be an outstanding event in the history of science in Ohio. To do justice to the event as a whole, to the officers and members who labored so long and so hard to bring the event to a happy fruition, and to the many notable scientists who contributed so generously of their time and talent to the success of the celebration, would require a very sizable volume. The determination on the part of the officers and members of the Academy to publish just such a volume, one that will be a memorial worthy of the event and the participants, in the not too distant future is very strong, and our hopes are very high that some way of bringing this about will be found.

In the meantime, it seems fitting that a very brief report of the meeting should be made and printed in the usual manner. Obviously many of the usual features of the annual meeting of the Academy had to be omitted or modified. This applies particularly to the fine sectional meetings and programs that usually form such a vital part of the annual meeting. Instead, the scientific portion of program took the form of symposia of great and general interest participated in by the most eminent scientists of the country, both home and abroad.

For example, on Friday morning (May 10), three concurrent symposia were discussed by the most eminent authorities: (1) A Symposium on *Hearing*, discussed by Dr. R. H. Stetson of Oberlin College and Dr. E. A. Culler of the University of Illinois; (2) A Symposium on the *Basic Factors in Conservation*, discussed by Dr. Guy W. Conrey of the Ohio Agricultural Experiment Station, by Dr. Frank J. Wright of Denison University, and by Dr. E. N. Transeau, Ohio State University; (3) A Symposium on *Radiation and the Cancer Problem*, ably discussed by Dr. E. U. Condon of the Westinghouse Research Laboratories, by Dr. Isadore Lampe, of the University Hospital, University of Michigan, and by Dr. Francis Carter Wood, of Saint Luke's Hospital, New York.

Friday afternoon was devoted to one great general meeting in the University Chapel at which three outstanding addresses were made: (1) "Forests on a Changing Earth" by Dr. R. W. Chaney, of the University of California; (2) "Application of Airplane Photography to Geographic Studies" by Dr. John L. Rich of the University of Cincinnati; and (3) "Industry and Science" by Dr. Charles F. Kettering of the General Motors Research Corporation.

Then on Saturday forenoon four concurrent symposia: (1) A Symposium on the Nervous System, discussed by Dr. Herbert S. Gasser, Director of the Rockefeller Institute, by Dr. R. W. Gerard, of the University of Chicago, and by Dr. John F. Fulton, of Yale University; (2) A Chemical-Physical Program, discussed by Dr. Edward Mack of the Battelle Memorial Institute, Dr. M. S. Newman, Ohio State University, and by Dr. H. S. Booth, Western Reserve University; (3) A Genetics-Speciation Program, discussed by Dr. Laurence H. Snyder, of Ohio State University, by Dr. Warren P. Spencer, of the College of Wooster, and by Dr. David C. Rife, Ohio State University; and (4) A Botanical Program in which Dr. A. E. Waller of Ohio State University, Dr. J. H. Gourley, of Ohio Agricultural Experiment Station, Dr. Paul B. Sears of Oberlin College and Dr. E. Lucy Braun participated.

The meeting really began on Thursday evening, May 9, with a very large general gathering in the University Chapel. At this first meeting the Governor of Ohio, the Honorable John W. Bricker, extended the greetings of the State of Ohio to the assembled scientists, and President Howard L. Bevis of the Ohio State University welcomed the Academy and its friends to the University, to which President William Lloyd Evans responded for the Academy. Following these exchanges of greetings, the audience was treated to a masterly address on "Sound Patterns," wonderfully illustrated, by Dr. Harvey Fletcher of the Research Staff of the Bell Telephone Company.

As usual, Friday evening was given over to the annual banquet, always a most interesting event. The banquet was held in the Hall of Mirrors at the Deshler-Wallick Hotel, with a capacity attendance, and was presided over by President-Emeritus William McPherson. The event of the annual banquet is always the Presidential Address. Doctor Evans chose for his topic, "A Present-Day Examination of the Postulates of John Dalton." He made the story or history of the atom as

revealed by the ever increasing scientific light of knowledge through the years most interesting and informing.

Just preceding the Presidential Address, Dr. James P. Porter of Ohio University gave a very full history of the Ohio Academy of Science during the fifty years of its existence.

Under the new constitution the only opportunity the Academy as a whole has to consider the business affairs of the Academy is at the annual banquet. It was therefore necessary to hear brief reports from officers and committees, to hold the annual election and transact any other business deemed proper. These reports will be published in full in the memorial volume (if and when published) and only a résumè given at this time.

The Nominating Committee nominated and the Academy elected the following officers for the ensuing year:

President . . . . Stephen R. Williams, Oxford
Secretary . . . . William H. Alexander, Columbus
Treasurer . . . . Edward S. Thomas, Columbus
Joint Administrative Board, O. J. S . . . {A. W. Lindsey, Granville / James R. Patrick, Athens
Trustee Research Fund . . . . Paul B. Sears, Oberlin
Committee on Conservation . . . . {T. H. Langlois, Columbus / J. D. Sayre, Wooster / D. M. DeLong, Columbus

The Committee on Membership reported the election of 127 new members during the year and the restoration of three. Fellowship in the Academy was bestowed by the Council on the following persons, viz.:

JOHN G. ALBRIGHT . . . . Case School of Applied Science
HARVEY CLAYTON BRILL . . . . Miami University
G. E. COGHILL . . . . Gainesville, Fla.
ELIZABETH ELEANOR COYLE . . . . College of Wooster
OLIVER DANIEL DILLER . . . . Ohio Agricultural Experiment Station
WILLIAM CLARENCE EBAUGH . . . . Denison University
PAUL E. FIELDS . . . . Ohio Wesleyan University
ALFRED BENJAMIN GARRETT . . . . Ohio State University
ROY I. GRADY . . . . College of Wooster
FRANK ALEXANDER HARTMAN . . . . Ohio State University
JAMES ARTHUR HERRICK . . . . Kent State University
CHARLES D. HODGMAN . . . . Case School of Applied Science
HARVEY EVERETT HUBER . . . . Ohio Northern University
HOWARD WILFRED JOHNSON . . . . Bureau of Plant Industry, U. S. D. A.
CHARLES F. KETTERING . . . . General Motors Research Corporation
HAROLD P. KNAUSS . . . . Ohio State University
ALFRED LANDE . . . . Ohio State University
ROBERT DONALD LEWIS . . . . Ohio State University
WARREN C. MILLER . . . . Bedford High School, Bedford, Ohio

M'DELLA MOON...Bluffton College
DWIGHT MUNSON MOORE...........................University of Arkansas
CHRISTIAN NUSBAUM.......................Case School of Applied Science
M. L. POOL..Ohio State University
MILTON PORTER PUTERBAUGH...............................Ashland College
HARMON A. RUNNELS...................Ohio Agricultural Experiment Station
ROBERT S. SHANKLAND.......................Case School of Applied Science
JULIUS F. STONE......................................Ohio State University
CLARENCE EGBERT TAFT..............................Ohio State University
MILTON B. TRAUTMAN..............................Franz Stone Laboratory
RICHARD THURMAN WAREHAM...........................Ohio State University
ABRAHAM H. WIEBE............................Tennessee Valley Authority
JOHN H. WOLFE.......................................Ohio State University

The meeting was characterized not only by an unusually rich program, excellent in every way, but by at least two other notable features: (1) The number and quality of the exhibits, assembled and arranged by the Committee on Exhibits under the enthusiastic and resourceful leadership of Dr. Glenn W. Blaydes of Ohio State University. Note that at the time of the printing of the program there were ninety-nine *centralized* and forty *fixed* exhibits ready for the opening day of the centennial; others came in later. These exhibits in themselves showed marked cleverness and ingenuity on the part of the exhibitors; (2) One of if not *the* most significant forward step made at this annual meeting was the organization of a *Junior Academy Section* of the Ohio Academy of Science, largely due to the persistent, intelligent, skillful, enthusiastic leadership of Dr. Charles W. Jarvis of Ohio Wesleyan University, materially aided in the final steps by the inspirational talks and helpful suggestions of Dr. Otis W. Caldwell of the American Association for the Advancement of Science. Special credit should also be given to Mr. Orville Linebrink of the Columbus Schools for his untiring aid in interesting other schools in the Junior Academy. We understand there are now some ninety science clubs, members of the Junior Academy and these are well distributed over the State. We wish we had the space and the ability to describe adequately some of these papers, demonstrations and exhibits put on by these youngsters; they would do credit to any group. Take as an example the "Dissecting of a Pig Embryo," a demonstration put on by four girls from the Walnut Hills High School of Cincinnati under the sponsorship of Miss Etta Elberg; or, the demonstration by two boys from the New Philadelphia High School entitled "Experiments Using Dry Ice," sponsored by Miss Leila E. Helmick. Both performed in a masterly manner.

There were other features, of course, and other items of

interest in the various reports but lack of space forbids further review, except that we must give a small part of the Treasurer's report that you may have some idea as to the financial affairs of the Academy. The report covers the year ending December 31, 1939, and was duly audited. See following.

As to the report of the Trustees of the Research Fund it may be sufficient to say that it shows grants paid $198.52, with a balance in the checking account of $193.93, and assets (bonds, stock, etc.) to the value of $1,737.50.

So much then for the Fiftieth Anniversary! May the One Hundredth Anniversary witness even greater things!

WILLIAM H. ALEXANDER, *Secretary.*

Report of the Treasurer

Dear Mr. Alexander:

I enclose a financial statement of the condition of the Ohio Academy of Science as of December 31, 1939. The books have been audited and the opinion of the auditor is herewith attached.

Cordially yours,

Eugene Van Cleef, *Treasurer.*

BALANCE SHEET AS AT DECEMBER 31, 1939

Assets

CURRENT EXPENSE FUND:
Cash in bank—Current...$ 27.37
Cash in bank—Semi-Centennial Celebration.......................   100.00
Undeposited Cash...   2.50

Total cash..$ 129.87
Dues receivable 1938...................................$ 75.00
Dues receivable 1939...................................   170.00

Total Dues receivable......................................   245.00
Bonds—Consolidated Federal Farm Loan 3% 1945–55............... 1,300.00

Total assets current expense fund...........................$1,674.87
RESEARCH FUND:
Cash on deposit.......................................$ 193.93
Banc Ohio Securities Company Stock (cost)...............   437.50
Bonds—Fort Hayes Hotel—Columbus, Ohio (cost)......... 1,300.00

Total assets research fund................................. 1,931.43

Total assets...$3,606.30

Liabilities, Deferred Credits and Net Worth

LIABILITIES:
None.
DEFERRED CREDITS TO INCOME:
Reserve for uncollected dues 1938 and 1939.......................$ 245.00
1940 dues collected in 1939.......................................   37.50

Total deferred credits to income...........................$ 282.50

NET WORTH:
Ohio Academy of Science—

Current expense fund—surplus	$1,292.37
Research fund—surplus	1,931.43
Semi-Centennial Celebration—surplus	100.00
Total surplus (schedule 1)	3,323.80
Total liabilities, reserves and net worth	$3,606.30

ANALYSIS OF CHANGES IN SURPLUS DECEMBER 31, 1939

Surplus, December 31, 1938		$3,414.98
Deduct:		
Decrease in surplus—current expense fund	$ 65.59	
Decrease in surplus—research fund	125.59	
Total deductions		191.18
Surplus—Current and Research Funds		$3,223.80
Surplus—Semi-Centennial Celebration		100.00
Total Surplus, December 31, 1939		$3,323.80

STATEMENT OF INCOME AND EXPENSE FOR THE YEAR ENDING DECEMBER 31, 1939

INCOME:

Dues for the year 1939	$1,202.50
Grants for research	150.00
Sale of publications	7.65
Interest on bonds	39.00
Total income	$1,399.15

OPERATING EXPENSES:

Speakers		$ 25.00
Clerical assistance		20.70
Postage and telegraph		85.75
Office supplies and expenses		25.55
Expenses of officers to meetings		62.70
Printing:		
Proceedings, Ohio Journal of Science	$138.25	
Other	155.87	
Total printing		294.12
Subscriptions, Ohio Journal of Science		675.00
Research grants		150.00
Secretary's honorarium		100.00
Safety Deposit box rent		3.30
Bond treasurer		5.00
Auditing expense		15.00
Bank charges		9.62
Total operating expenses		1,471.74
Net operating deficit for the year 1939		$ 72.59

OTHER INCOME:
Dues collected for prior years:

1937	$ 2.50
1938	90.00
Total other income	$ 92.50

OTHER EXPENSE:

1938 subscriptions, Journal of Science	85.50
Net other income	7.00
Net deficit for the year	$ 65.59

STORAGE TESTS WITH SEED CORN

J. D. SAYRE*

INTRODUCTION

Many tests have been made on the longevity of seed corn. Those described in this paper, however, differ from most others, because the seeds were stored in large test tubes with a glass seal to be absolutely sure that there was no exchange of gases between the seeds and the outside air. In most tests of longevity no attempt has been made to preclude exchange of gases. One of the objects of this test was to study the effect of different gases on the longevity of the seeds; thus it was necessary to have a perfect seal to maintain the gas content.

EXPERIMENTAL PROCEDURE

Large culture tubes, 1 by 8 inches, were used as containers for the seed. Each tube held about 100 seeds of Clarage seed corn. The procedure in sealing the tubes was rather simple. A bottleneck was drawn in the tube near the open end in a hot flame, and an opening left just large enough for a single seed to pass through easily. After the tubes were filled with seeds, a wad of asbestos fiber was placed on top of the lot and the tubes were sealed in a small hot flame. This was done quickly so that there was no danger of injuring the seed from the heat.

The tubes were filled with gas by placing a small glass tube through a two-hole rubber stopper to the bottom of the tube and forcing gas through the seeds. Carbon dioxide, oxygen, and nitrogen were used. The carbon dioxide was generated from hydrochloric acid and limestone and washed twice with sulphuric acid to adjust the vapor pressure to that of the seeds. The gas was forced through the seeds for 10 minutes. The outlet tubes were then closed with pinchcocks, and the sample was left overnight. The next day carbon dioxide was forced through the seeds for 10 minutes more and the tube was sealed while the gas was still passing into the tube. The same procedure was used in filling the tubes with nitrogen except that the nitrogen was washed twice with pyrogallic acid to remove oxygen.

Gas many times the volume of the tube was passed through each in order to remove as much of the air as possible. It is questionable whether the last trace of air could be removed without some other treatment, such as heating or a high vacuum, but these treatments could not be used because of danger of injury to the seeds. Oxygen was

passed through the seeds for 5 minutes and the tubes were sealed while it was entering the tube. This treatment would not displace all the air in the tube but would raise the oxygen pressure very high.

The seeds were stored at several different temperatures. It was necessary to use available facilities for this work; thus, the rooms where they were stored were not at constant temperatures. Some stored in the soil biology culture room, which is maintained at a very high temperature, somewhere around 30° C. Others were kept in a basement seed storage room whose temperature is somewhat lower. Two rooms in the animal industry refrigerator were used, one in which apples are stored, +3° C. to +4° C., and which never freezes, and another which is kept below freezing at all times, —2° C. to —9° C. The other room used was the low-temperature room in the Agronomy Service Building, which is kept at —25° C. but which may be changed at times for other experiments for a week or so to as high as —7° C.

Results

The results of these tests are shown in Tables I and II.

TABLE I

SUMMARY OF PERCENTAGE GERMINATION OF CORN SEEDS OF DIFFERENT MOISTURE CONTENT STORED AT ROOM TEMPERATURES AND BELOW 0° C.

PERCENT MOISTURE	½ YEAR		2 YEARS		4 YEARS		6 YEARS	
	Room	—0°C.	Room	—0°C.	Room	—0°C.	Room	—0°C.
7.5	92	95	89	87	96	88	80	88
11.0	98	90	91	96	82	88	81	95
14.6	88	95	0	82	69	86	15	80
18.2	0	73	0	34	0	51	0	13

Significant difference = 8.

TABLE II

SUMMARY OF PERCENTAGE GERMINATION OF CORN SEEDS SEALED WITH DIFFERENT GASES AND STORED AT THREE TEMPERATURES

GAS CONTENT	1 YEAR			3 YEARS			5 YEARS		
	30° C.	3° C.	—25°C.	30° C.	3° C.	—25°C.	30° C.	3° C.	—25°C.
Air	82	91	93	76	94	92	39	90	92
Carbon dioxide	84	87	91	84	92	92	39	95	91
Oxygen	78	84	91	0	84	94	0	90	91
Nitrogen	89	91	93	27	90	80	21	92	86
Open to air	84	93	84	88	92	86	66	83	90

Significant difference = 13.

It is rather hard to evaluate these results because any direct comparison with checks was not made. It is possible, however, to compare results when moisture content, time of storage, and storage temperature were in all combinations with each other, and when gas content, time of storage, and temperature of storage were combined similarly. A statistical analysis of these data as outlined by Brandt (2) was carried out. Since the values of germination are given in percentages and since they vary from 0 to 98, they have been changed to values of angles of equal information, as suggested by Bliss (1). The factorial analysis was carried out on the values and the error obtained converted back to percentages. The homogeneous variances of the interactions were considered as the error term in determining the significance of the main comparisons. These results show that moisture content, temperature of storage, and time of storage were the only significant main comparisons.

A summary of the main comparisons is given on page 5, and a careful examination of these results shows that there was no difference between the two low moisture contents but that great differences occurred at the higher contents. The germination of the seeds was much better at the low storage temperatures, but here also no difference was noted between those stored at —25° C. and at about 0° C.

Germination has gradually decreased with time in both lots of seed. The most interesting results are shown by the seeds sealed in atmospheres of single gases. There was no difference in germination of the seeds stored in carbon dioxide and in air, but significant decreases were shown by those sealed in nitrogen and in oxygen. From a theoretical standpoint, the seeds stored in oxygen, especially at a high temperature, should die because of increased respiration, and those without oxygen should die because of lack of respiration. This was not so, however, because those in carbon dioxide showed no decrease in germination when compared with air, whereas those sealed in nitrogen were injured some. Our idea of the respiration requirement for viable seeds may not be correct. In fact, it may be that respiration is a detriment to the longevity of seeds and that any external or environmental condition which will decrease respiration will lengthen the life of the seeds.

These data do not show that seeds were benefited by storage in carbon dioxide when compared with air, but neither do they show that they were injured. Beneficial results were obtained by Kondo (3) and Kondo and Okamura (4), (5), with rice seeds in Japan. Rice seeds which died in 7 months when stored in the air germinated 98 per cent after 4 years when stored in airtight containers with either air or carbon dioxide.

These experiments have not run long enough yet to see whether any benefit results from carbon dioxide storage, because the seeds stored in air are still germinating very high. The experiment is being continued and enough tubes are still available to continue the test for 10 to 15 years, as they will be tested for germination only every 2 or 3 years.

Summary of main comparisons of Table I:

Percentage moisture   *Percentage germination*

    7.5............................. 89
   11.0............................. 90
   14.6............................. 64
   18.2............................. 21

Temperature of storage

   Room........................... 55
   —0° C. ......,................. 78

Years of storage

   ½................................ 79
   2................................ 60
   4................................ 70
   6................................ 57

Summary of main comparisons of Table II:

Gas content   *Percentage germination*

   Air............................. 83
   Carbon dioxide.................. 84
   Oxygen......................... 68
   Nitrogen....................... 74
   Open to air.................... 85

Temperature of storage

   +30° C. 57
   + 3° C. 90
   —25° C. 90

Years of storage

   1................................ 88
   3................................ 78
   5................................ 71

CONCLUSIONS

Seed corn was not injured by sealing it in glass test tubes with air or carbon dioxide, but it was injured by sealing it in oxygen or nitrogen.

Low-temperature storage of seed corn benefited germination greatly, for seed which remained viable for only 6 months at a high temperature still grew after 6 years of storage at a low temperature.

Low moisture content, as has been known for years, is necessary for proper storage of seed corn.

LITERATURE CITED

(1) **Bliss, C. I.** 1938. The transformation of percentages for use in the analysis of variance. Ohio Jour. Soc. 38: 9–13, No. 1.

(2) **Brandt, A. E.** 1937. Factorial design. Jour. Amer. Soc. Agr. 29: 658–667. No. 8.

(3) **Kondo, Mantaro.** 1926. The storage of rice and change of its physical properties during this period. Ber. Ohara Inst. landw. Forsch. 3 (2): 153–175.

(4) **Kondo, Mantaro, and T. Okamura.** 1929. On the effect of airtight and carbon dioxide upon the storage of rice. Ber. Ohara Inst. landw. Forsch. 4 (1): 1-18.

(5) **Kondo, Mantaro, and T. Okamura.** 1930. Germination power, analyses and vitamin-B of hulled rice stored during 4 years either airtight or in carbon dioxide. Ber. Ohara Inst. landw. Forsch. 4 (3): 343–347. pl. 28.

Photographs

Elementary Photography in one volume offers an amateur photographer a complete and concise publication on the art and science of making pictures. The information presented is well organized, illustrated and expressed in simple language which can be readily understood by anyone having had high school training or its equivalent. The following are some of the twenty-four interesting chapters; historical background, elementary photographic optics, aberrations in lenses, camera parts and accessories, cameras and camera testing, film sensitivity and exposure, development of negatives, fixing and washing negatives, contact printing, photography of colored objects, photography of moving objects, photography by artificial light, negative troubles, reduction and intensification, projecting printing, composition, projection control, finishing the print, toning prints, natural color photography, lantern slides and transparences, etc.

As an amateur photographer the writer has derived considerable practical knowledge from the contents of the various chapters. If photographers will put into practice the many suggestions made in the various chapters, few, if any, mistakes would occur in amateur picture making.—*Alvah Peterson.*

Elementary Photography, by Gilford G. Quarles. VII + 350 pp., 83 figs. New York, the McGraw-Hill Book Co., 1940. $3.00.

Snedecor's Statistical Methods—Revised

This textbook of statistics, though written primarily for the biologist, is commonly turned to by workers in many other fields who wish to read what is perhaps the fullest account now available of the small sample methods of R. A. Fisher and others. Its author has probably had more experience in the practical application and teaching of these methods than any other person in this country. His textbook, based on that experience, has established several features of presentation as standard in statistics manuals designed for the biologist—use of but little mathematical formulation, lengthy discussion of worked examples, and emphasis upon experimental design and its implications in statistical analysis.

The revised edition features no changes and but few additions to the former chapters. These new sections deal with (1) rates and percentages and their comparison with regression coefficients, (2) the treatment of percentages in the analysis of variance and other difficulties arising from correlation between mean and variance, (3) the treatment of data involving disproportionate subclass frequencies and modifications of the randomized block experiment, and (4) methods of multiple covariance embracing four or more variables.—*C. W. Cotterman.*

Statistical Methods, by George W. Snedecor. xiii+388 pp. Ames, Iowa, the Collegiate Press, Inc. Revised, 1938. $3.75.

THE MICROSCOPIC FLORA AND FAUNA OF
TREE HOLES*

JAMES B. LACKEY

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Stream Pollution Investigations Station
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There are few if any natural environments on this earth without their inhabitants. This applies either to mammals or protistan organisms; the snowfields and the hot springs have algal populations, and the most acid streams may support a rich microscopic life.

In 1936, the writer was investigating the breeding of mosquitoes in North Alabama. In an old limestone sink whose shallow central pond was occupied by a grove of Tupelo gum (*Nyssa aquatica*) some twenty tree or stump holes were found in an area of about an acre. Most of these contained water, and various ones of them were breeding places for six species of mosquitoes. Because one of these mosquitoes, *Aedes thibaulti* Dyar and Knab, is relatively rare, and practically nothing was known of its breeding habits, a careful study was made of the flora and fauna of these tree and stump holes, (1). Since then, additional tree holes in Ohio have been investigated and their interesting inhabitants studied.

Tree holes that contain water are rare. In the spring, or after a long rainy spell, many will be partly filled with water, but most frequently they will either be filled with dirt and debris, or else the wood is too porous to hold water. Occasionally one will be found which is in effect a permanent pool. With reference to their contained water they may be grouped roughly as those in the tops of living stumps, those in crotches or in the tops of protruding limbs or knots, and those in the sides of trees or limbs. The first two types may catch considerable rain water, but the last usually gets only small amounts of water which runs down the side of the tree.

Holes so far studied, with few exceptions, have contained rain water, that is, have been free from contamination by surface ground water. But their fluid is rarely clear; either enough

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*Prepared for presentation at meeting of Ohio Academy of Science, Cincinnati, Ohio, April 14, 1939.

extracted material is picked up in running down the tree trunk, or else the debris and rotting wood in the hole provides enough so that a brown to black color obtains. Suspended materials are rare; the few determinations made of dissolved oxygen have shown variable amounts, but usually a high percentage of saturation. Light fluctuates with the size of the hole opening. Chemical analyses have not been made, beyond determinations for tannates and hydrogen ion concentration. Often a rather "sour" smell has been noted, and it was anticipated from this and because of suspected tannic acid that the pH would be on the acid side. However, hydrogen ion concentrations lower than pH 5.8 were not found, and in a few cases slight alkalinities obtained. For these latter, the strong odors indicated the presence of putrefactive processes yielding amines. Temperatures tended toward uniformity, that is, warmer in winter than surface ground waters and decidedly lower in summer. No macroscopic animals except insect larvae and mites have been found in any of the holes so far examined. In a few, weeds had sprouted and some contained moss.

This report covers observations on 26 tree holes, all in living trees and distributed as follows: Tupelo gum, 13; Black gum, 1; American elm, 3; Maple, 3; White oak, 2; Blackjack oak, 1; Red oak, 1; Sycamore, 1; and Sweetgum, 1. In addition, four tree holes containing water were examined and no living protozoa were found. In Table No. 1 are tabulated the data observed. Material from one of these latter subsequently developed a thriving culture of *Polytoma uvella* Ehrenberg. No observations were made on material from the remaining three. Three of the tree holes were periodically flooded by water from the pond in which the Tupelo gums were growing, and it is probable that when the Little Miami River is excessively high, the hole in the Sycamore is flooded.

Entrances to the holes varied from about eight inches in diameter to about one-half inch. One hole which contained water whenever visited, was about 20 inches deep, and two inches in internal diameter, with an opening about $\frac{3}{4}$ inch in diameter. It usually had about 8 inches of water and an inch of debris on the bottom.

About 140 species of algae and protozoa were recovered from these 30 holes. Since most of the holes were visited but once and since cultures from them usually developed additional species under laboratory conditions, it seems probable that a

much larger list of organisms could be compiled. The hole which gave the greatest number of species was Number 3, which showed 63 species. This hole was periodically flooded, but its organisms were more abundant than in the pond, and many of them were not common to the pond. On one occasion its water was deep brown, due to enormous numbers of *Trachelomonas reticulata* Klebs. It contained such species as *Chrysococcus rufescens* Klebs, *Cryptochrysis commutata* Pascher, *Chroomonas acuta* Utermohl, *Euglena mutabilis* Schmitz, *Trachelomonas rugulosa* Stein, *Phacus hispidula* (Eichw.) Lemm., *Cryptoglena pigra* Ehrenb., *Astasia Klebsii*, Lemm., *Menoidium tortuosum* Stokes, and *Trigonomonas compressa* Klebs. These are forms which the writer has not found to be widespread in natural bodies of water. There was also a species of Trachelomonas and one of Menoidium not referable to described species. On the other hand, there were forms which were very common to decaying submerged vegetation, as *Chilomonas paramecium* Ehrenberg, and such cosmopolitan forms as *Cyclidium glaucoma* O. F. M.

The large species list for this particular hole might be accounted for by the chances for frequent entry of water from the pond. But the development therein, in large numbers, of forms not common to, or not observed in the pond at all, argues for the existence of specific microclimatic conditions in the tree hole favorable for such organisms. That this is the case .is further borne out by other tree holes. Holes Numbers 10 and 12 had 16 and 34 species respectively, and were so high that only rain water could trickle in. Hole Number 10 was the breeding place for four species of mosquitoes, so it is surprising that its list of organisms comprises even 16 species. Its organisms were not unusual, but most of the Chlamydomonas and Chlorogonium in it were colorless or nearly so, and in a large population of *Blepharisma undulans* Stein, the pink color was either completely gone or partly so. Hole Number 12, with 34 listed species showed some unusual forms as *Acinetactis mirabilis* Stokes, about whose validity Pascher (2) is perhaps dubious, and *Dactylochlamys pisciformis* Lauterborn. Green flagellates were scarce in this hole, but it contained *Phacus triqueter* (Ehrenb) Dujardin—and they were all colorless or nearly so! The existence of these colorless, but apparently thriving forms of normally green flagellates is further evidence for specific microclimatic factors.

A comparison of the organisms in all holes shows a strong tendency to recur. It has been stated elsewhere (3) that only very few protozoa or flagellates might be reasonably expected in a random sample of a natural water, as a stagnant pool, or quiet spot close to a river bank. If we take the entire 30 holes

TABLE I

THE LOCATION OF 26 TREE HOLES INVESTIGATED FOR MICROSCOPIC LIFE, SHOWING LOCATION, KIND OF TREE, HYDROGEN ION CONCENTRATION WHEN OBSERVED, AND LISTING THOSE SPECIES WHICH OCCURRED IN FOUR OR MORE OF THE HOLES

Hole No.	Location	Kind of Tree	pH	No. Species	*Oxytricha* sp.	*Halteria grandinella*	*Metopus* sp.	*Vorticella* sp.	*Distigma proteus*	*Menoidium incurvum*	*Colpoda aspera*	*Oicomonas* sp.	*Menoidium* sp.	*Chilodonella uncinatus*	*Cinetochilum margaritaceum*	*Cyclidium glaucoma*	*Astasia inflata*	*Chlamydomonas* sp.	*Bodo globosus*	*Hexamitus crassa*	*Polytoma uvella*	*Trachelomonas volvocina*
1	Alabama..	White Oak.........	......	11	x		x	x	x									x				
2	"	Blackjack Oak.....	......	2								x		x								
3	"	Tupelo Gum........	6.0	61	x	x	x	x	x	x		x	x	x		x	x	x		x		x
4	"	" "	......	3																	x	
5	"	" "	......	1								x										
6	"	" "	6.2	13	x	x		x							x						x	
7	"	" "	6.0	6				x							x		x					
8	"	" "	......	2									x									
9	"	" "	......	10			x		x	x										x		
10	"	Black Gum........	6.1	16	x	x						x										
11	"	" "	......	4											x			x				
12	"	" "	6.0	35	x	x	x	x	x	x	x	x	x	x		x			x	x		x
13	"	" "	5.8	8			x	x														x
14	"	" "	......	12	x								x				x			x		x
15	"	" "	6.0	6		x		x					x									
16	"	Sweet Gum........	......	35	x																	
17	"	Tupelo Gum.......	6.1	8		x			x										x	x		
18	"	White Oak.........	......	2							x		x	x	x	x	x	x	x		x	
19	Ohio.......	Maple.............	7.0	9					x		x											
20	"	Maple.............	......	4				x			x											
21	"	American Elm.....	7.2	1							x	x										
22	"	" "	7.2	6															x		x	
23	Kentucky.	Red Oak..........	......	6																		
24	Ohio.......	American Elm......	7.1	1																		
25	"	Sycamore..........	7.1	27				x	x													
26	"	Maple.............	7.1	1																		

examined for this study, some of the organisms occur with a relatively high frequency. This tendency is shown in Table I. Table II lists all the protozoa and algae found in the 26 holes containing living organisms. While the percentage of occurrence

in samples is not strikingly large, it is nevertheless decided, and is further corroboration of some sameness in these habitats.

The water in beech holes (Fagus sylvatica) was studied by von Brandt (4) and his findings indicate that the environment might be restrictive. He listed only six protozoa from tree holes, but Mayer (5) in a "large number" of beech holes found 34 additional species, 14 of which are included in our list. His list and ours contain many organisms characteristic of waters rich in organic contaminants.

It is interesting to speculate on how these forms first entered tree holes which now have no connection with ground water. Upward growth of the hole may be postulated in a few cases. Upward migration of some forms in the film of water along the bark in wet seasons may also be taken into account. Some of the forms are those which Unger (6) and others have shown to be found on vegetation in the form of cysts: But for others, cysts are as yet unknown, and these could hardly be transported to the tree holes by winds or animals. Perhaps a combination of methods is the easiest way to account for entrance. A few high tree holes were investigated but none had any water in them.

It is worth noting that algae, exclusive of the flagellated forms, were largely absent from these situations. Pleurococcus was probably the most frequent, but despite the diffuse light present in some of the situations, Protococcales were almost wholly lacking, only a few diatoms were seen, and no blue green algae were recorded. It may be inferred that there was too much organic matter present for the development of most algae, since several species of algae were found in the Tupelo gum pond, and at least some of the holes admitted enough light for chlorophyll bearers.

Altogether the collection of organisms studied herein| is interesting because it exhibits a tendency to be an environmental group; because of its unusual forms; because of the tendency for some of the green flagellates to lose their chlorophyll and assume a saprophytic existence; and because of the evidence which it may offer for microclimatic factors in these small environmental niches.

TABLE II
LIST OF ALL ORGANISMS IDENTIFIED IN TWENTY-SIX TREE HOLES

BACILLARIEAE
  Pennales
    Naviculineae
      Navicula sp.
  Chrysophyceae
    Chrysococcus rufescens

CRYPTOPHYCEAE
    Chilomonas oblonga
    Chilomonas paramecium
    Chroomonas acuta
    Cryptochrysis commutata
    Cryptomonas erosa
    Cryptomonas ovata
    Cyathomonas truncata

CHLOROPHYCEAE
  Volvocales
    Chlamydomonas sp. 1
    Chlamydomonas sp. 2
    Chlamydomonas sp. 3 colorless
    Chlorogonium euchlora
    Chlorogonium elongatum
    Chlorogonium sp. colorless
    Polytoma uvella
    Polytomella citri
  Ulrotrichales
    Protococcus viridis
    Sphaeroplea sp.
    Ulothrix zonata
    Unidentified algal filaments

EUGLENOPHYCEAE
  Euglenaceae
    Cryptoglena pigra
    Euglena acutissimum
    Euglena gracilis
    Euglena gracilis (?) colorless
    Euglena mutabilis
    Euglena pisciformis
    Euglena polymorpha
    Euglena tripteris
    Euglena viridis
    Lepocinclis ovum
    Phacus hispidula
    Phacus longicauda
    Phacus pyrum
    Phacus Stokesii
    Phacus triqueter
    Phacus sp., colorless
    Trachelomonas euchlora
    Trachelomonas hispida
    Trachelomonas intermedia
    Trachelomonas reticulata
    Trachelomonas rugulosa
    Trachelomonas verrucosa
    Trachelomonas volvocina
    Trachelomonas sp.
  Astasiaceae
    Astasia Dangeardi
    Astasia inflata

Astasia Klebsii
Astasia sp.
Distigma proteus
Menoidium incurvum
Menoidium tortuosum
Menoidium sp.

Peranemaceae
  Anisonema ovale
  Entosiphon ovatum
  Entosiphon sulcatum
  Heteronema acus
  Notosolenus orbicularis
  Peranema granulifera
  Peranema ovalis
  Peranema trichophorum
  Petalomonas Steinii
  Scytomonas pusilla
  Unidentified flagellates—several
    species

MASTIGOPHORA
  Pantostomatinae
    Acinetactis mirabilis
    Bodopsis sp.
    Cercobodo crassicauda
    Cercobodo longicauda
    Mastigamoeba reptans

PROTOMASTIGINAE
  Oicomonadaceae
    Oicomonas obliqua
    Oicomonas ocellata
    Oicomonas sociabilis
    Oicomonas Steinii
    Oicomonas sp.
  Craspedomonadaceae
    Monosiga ovata
  Monadaceae
    Monas minima
    Monas vivipara
    Monas vulgaris
  Bodonaceae
    Bodo angustus
    Bodo globosus
    Bodo lens
    Pleuromonas jaculans
  Tetramitaceae
    Tetramitus pyriformis
  Distomatinae
    Hexamitus crassus
    Trepomonas agilis
    Trepomonas rotans
    Trigonomonas compressa

SARCODINA
  Actinopoda
    Acanthocystis aculeata
    Actinophrys sol
    Heterophrys myriapoda

TABLE II (*Continued*)

Rhizopoda
  Proteomyxa
    Nuclearia simplex
  Amoebaea
    Arcella vulgaris
    Amoeba radiosa
    Amoeba tachypodia (?)
    Amoeba sp. 1
    Amoeba sp. 2
    Centropyxis aculeata
    Cochliopodium bilimbosum
    Difflugia globosa
    Difflugia pyriformis
    Euglypha alveolata
    Hartmanella hyalina
    Trinema lineare
    Vahlkampfia albida
    Vahlkampfia guttula
    Vahlkampfia limax
INFUSORIA
  Ciliata
    Holotrichida
      Chilodonella uncinatus
      Cinetochilum margaritaceum
      Colpidium colpoda
      Colpoda aspera
      Cyclidium sp.
      Cyrtolophosis mucicola
      Dactylochlamys pisciformis
      Drepanomonas revoluta

Drepanomonas sphagni
Frontonia acuminata
Holophrya discolor
Lagnus simplex
Lionotus fasciola
Microthorax sulcatus
Nassula aurea
Spathidium spathula
Heterotrichida
  Blepharisma undulans
  Metopus sigmoides
  Metopus sp.
  Saprodinium sp.
Oligotrichida
  Halteria grandinella
  Strombidium sp.
Hypotrichida
Aspidisca costata
Holosticha sp.
Oxytricha fallax
Oxytricha sp.
Stylonichia pustulata
Uroleptus sp.
Peritrichida
  Opercularia sp.
  Pyxidium sp.
  Vorticella spp.
Unidentified ciliates, several species

SUMMARY SHOWING DISTRIBUTION

Bacillarieae	1	Infusoria		
Chrysophyceae	1	Holotrichida	16	
Cryptophyceae	71	Heterotrichida	4	
Chlorophyceae		Oligotrichida	2	
Volvocales	8	Hypotrichida	6	
Ulotrichales	5	Peritrichida	3	
Euglenophyceae	42	Flagellata	81	
Pantastomatinae	5	Ciliata	31	
Protomastiginae	14	Sarcodina	19	
Distomatinae	4	Others	6	
Sarcodina				
Actinopoda	3			
Rhizopoda	16	137		

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THE SOIL AS AN ECOLOGICAL FACTOR IN THE ABUNDANCE OF AQUATIC CHIRONOMID LARVAE

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INTRODUCTION

In recent years much attention has been given to the restocking of our lakes, rivers and streams with fish. Along with this restocking program there has been an intensive study of the food cycle of the fish. These studies have shown that chironomid larvae are very important in the food cycle of the game fish. Since the larvae of the Chironomidae are so important, a study of the factors influencing their abundance should be considered along with the restocking program.

Most species of aquatic chironomid larvae in pools are found burrowing in the river bottom soil to a depth of 2 inches. They are also found in decaying leaves which are mixed with the soil. Since the chironomid larvae are found in these conditions, the writer believes the following points should be considered in order to determine if the soil is an important factor in the abundance of chironomid larvae.

1. Type of soil
2. Organic matter content.
3. pH of the soil.
4. Nitrate content of the soil.

The author wishes to express his gratitude to Dr. D. M. DeLong for his excellent advice and interest during the working of this problem.

Many thanks are also due Mr. E. L. Wickliff of the Ohio Division of Conservation who, not only suggested this problem, but made it possible by furnishing the necessary equipment and transportation.

LITERATURE REVIEWED

Sullivan (1929) states that abundant chironomid larvae are found in all kinds of habitats. He did not give a description of the various types of habitats found or the number of chironomid found in each. There was no indication as to how many chironomid larvae should be considered as "abundant."

Jewell (1922) states that plenty of chironomid larvae were found but again there is no indication as to how many should be considered as "plenty." She states that no burrowing ephemerids were found in an acid stream but there were any numbers of chironomids. She states that the pH is a limiting factor for the burrowing mayfly nymphs but does not affect the chironomids.

Krecker (1933) gives a definite count of chironomid larvae per square yard and at the same time considers the type of soil as an important factor. In his study he found 60 chironomids per square yard of sand and only 20 in clay. Since this study was carried on in Lake Erie, its results cannot be compared with those in a stream except that it shows the type of bottom soil is important in the abundance of chironomid larvae.

Stehr and Branson (1938) made a number of population studies on sandy riffles and sandy pools. Their average mean count per square yard for February in a sandy riffle was 0 while the average mean count in a sandy pool was so small that it was not recorded. This paper shows that sand is not considered very productive as far as chironomid larvae are concerned.

Gersbacher (1937) in his very excellent paper on the development of stream bottom communities, states that in sand very little life can exist. According to him, the highest count of chironomids that could exist in his studies was 33.8 per square yard.

In this paper he states that as soon as algae and other detritus, which provide food and hiding places for chironomid larvae, starts accumulation, a count of 250 per square yard was considered low in many of these areas. This seems to show that there is a correlation between organic content and abundance of chironomids.

In mud bottom communities he found as high as 120 chironomids per square yard, but, if the pool is stable for the burrowing Mayflies, *Hexagenia*, will start migrating in with a corresponding decrease in the chironomid population. Silt and an accumulation of detritus is necessary for the burrowing mayfly nymphs.

PROCEDURE

The winter quarter was selected as the time in which to carry on the field work for the following reasons: First, the population

is more constant throughout the winter than the spring, summer and fall months. This is due to the fact that there is no emergence of chironomid larvae. Secondly, the larvae that hatched late in the fall would be large enough to be easily seen and handled. Finally, the larvae would remain more or less constant in size through the winter months because of the low metabolic rate which exists during low temperatures.

Blacklick Creek in Franklin County, Ohio, was selected as the stream in which to do most of the field work. However, a few samples were taken from Big Walnut Creek, Alum Creek and Olentangy River. Not as many samples were taken as the writer desired because of the flood conditions which sometimes made collecting impossible.

The soil samples were taken by the Peterson trap, which is one of the standard instruments for population studies of aquatic insects. As soon as a sample was obtained, it was placed in a 40 mesh net and as much soil as possible was washed out. The remaining material was then placed in a labeled bucket in which it was taken to a laboratory. There the larvae were picked out and counted. Finally the insects were placed in a 4 per cent solution of formaldehyde.

Observations show that the greatest depth the chironomids burrow is 2 inches. The mayfly nymphs, *Hexagenia*, burrow to a depth of $1\frac{3}{4}$ to 2 inches. Each sample was composed of a composite of 4 hand trowel samples which were taken around the Peterson samples at a distance of 1 foot. The composite sample was placed in a half pint jar and conveyed to a laboratory where it was put in a cold air cabinet and kept at a temperature of 2° C. in order to prevent bacterial growth until the time of testing. Because the Peterson trap cannot be used in a rubble riffle, all samples were taken in pools. They were obtained at a water depth of $2\frac{1}{4}$ to 3 feet.

The soil samples at the time of analyzing were dried in an oven at a temperature of 50° C. The following standard methods were used in analyzing the soil:

1. Glass electrode for pH.
2. Phenol disulphonic acid for nitrates.
3. Pipette method for soil types.
4. Chromic acid digestion method for content of organic matter.

The basis used for classification of soils was as follows:

Soil Particles	*Diam. in mm.*
Clay	.002 or less
Silt	.002—.05
Sand	.05—2.0
Gravel	above 2.0

Soil textures were defined as follows:

A. Soils containing up to 20 per cent silt and clay.
    1. Sand..............19 per cent or less silt and clay.

B. Soils containing 20 per cent to 30 per cent silt and clay.
    1. Sandy loam........20 per cent or more fine gravel; coarse and medium sand.
    . 2. Fine sandy loam...30 per cent or more fine sand; 25 per cent or less gravel; coarse and medium sand.
    3. Sandy clay........20 per cent or more silt.

C. Soils containing 50 per cent or more silt and clay.
    1. Loam.............20 per cent or less clay; 50 per cent or less silt.
    2. Silt soil..........20 per cent or less clay; 50 per cent or more silt.
    3. Clay loam.........20 to 30 per cent clay; 50 per cent or less silt.
    4. Silty clay loam.....20 to 30 per cent clay; 50 per cent or more silt.
    5. Clay.............30 per cent or more clay.

Gersbacher (1937) states that the total population of specific type in river bottom pools remain constant. When mayfly nymphs migrate in a pool there is a corresponding decrease in the number of chironomids. The total population was the number of chironomids plus the chironomids equivalent of the mayfly nymphs. The equivalent was determined by the amount of water displaced by the mayfly nymphs and chironomids. Results show that 20 chironomids displaced the same amount of water as one mayfly.

DISCUSSION OF RESULTS

The analysis of each sample for soil texture, pH, per cent of organic content and the chironomid population is shown in Table I. The tests for available nitrates are not listed because Nos. 6, 18 and 20 showed possible traces. Therefore, available nitrates in the soil is not a factor in fresh water streams, because

as shown in Table I they do not influence the chironomid population at all.

It is interesting to note in Table I that the pH of the soil samples varied from 7.3 to 8.5. This shows a very narrow range of 1.2. Since the range is so narrow, no conclusion can be drawn although Jewell (1922) states that the pH has no influence as a factor in the abundance of chironomids.

TABLE I

THE ANALYSIS OF EACH SAMPLE FOR SOIL TEXTURE, PH, PERCENT OF ORGANIC
CONTENT AND THE CHIRONOMID POPULATION

Sample	Soil Type	pH	Percent Organic Content	Chironomids per sq. yd.
1	Sand.....................	7.7	0	1,375
2	Silt-loam.................	8.2	1.40	1,727
3	Sandy-loam..............	7.6	1.37	256
4	Sand.....................	7.6	0.29	1,738
5	Loam.....................	7.6	1.75	5,379
6	Sandy-clay..............	7.7	2.74	1,762
7	Sandy-loam..............	7.9	1.46	2,783
8	Loam.....................	7.6	1.98	517
9	Sandy-clay..............	7.6	1.62	605
10	Clay-loam................	7.5	1.33	3,014
11	Clay-loam................	7.3	2.39	9,933
12	Sand.....................	7.6	0.89	132
13	Clay-loam................	7.7	2.23	3,140
14	Sand.....................	7.9	0	539
15	Sandy-clay..............	7.7	1.08	572
16	Sandy-clay..............	7.7	1.64	4,169
17	Sandy-loam..............	8.2	0.89	979
18	Clay-loam................	7.9	3.49	946
19	Clay-loam................	7.8	3.60	6,638
20	Loam.....................	7.7	2.86	2,475
21	Sandy-clay..............	7.7	1.59	6,116
22	Sandy-loam..............	8.1	0.40	4,665
23	Sand.....................	8.5	0.23	649

In Table II the samples of each type of soil are averaged for per cent of organic content, pH, and the chironomid population.

The lowest average population of chironomids was 387 in sand. The finer the texture of the soil, the more abundant the chironomids. The finest of these soils, the clay-loam, contained an average count of 4,723. This shows that there were approximately seven times as many chironomids in the clay-loam as in the sand. This agrees with Gersbacher (1937), who also found approximately seven times as many in the mud, which was the finest type of soil, as in the sand.

Sullivan (1929) stated that abundant chironomids were found in all types of habitats. Table II shows that the number of chironomids vary greatly with the different types of soil. This disagrees with Sullivan in that their abundance is determined by the type of soil in the pools which the chironomids habitat.

TABLE II

THE AVERAGE PERCENT OF ORGANIC CONTENT, PH, AND THE CHIRONOMID POPULATION FOR EACH TYPE OF SOIL

Soil Type	pH	Percent Organic Content	Chironomids per sq. yd.
Sand.........................	7.8	0.22	387
Sandy-loam...................	8.0	1.03	2,176
Sandy-clay...................	7.7	1.74	2,843
Silt-loam*...................	8.2	1.40	1,727
Loam........................	7.8	2.19	2,790
Clay-loam...................	7.6	2.61	4,723

*Since only one sample was taken, it is disregarded in the general conclusions. However, it is very interesting as a comparison.

As the percentage of organic content increases, the population of chironomids does likewise. In the silt-loam type there is a drop in the organic content and of the population count. However, this can only be considered an interesting observation, since only one sample was obtained in that type of soil. Gersbacher (1937) states that as soon as algae and other detritus accumulate in sand, there is an increase in population. Table II shows that there is a definite correlation between the organic content of the soil and the population of Chironomidae. Therefore it can be stated that the organic content is a factor, which is correlated with the soil type, in the abundance of chironomid population.

The pH in Table II ranges from 7.6 to 8.2. The average range was 0.6. As previously stated, the range is so small that it cannot be considered as a factor.

In Table III the average of the soil types, organic content, and the total population, (which is the chironomid population plus the chironomids equivalent of the *Hexagenia*), are compared.

Gersbacher (1937) states that when conditions are suitable for *Hexagenia* nymphs, we have a migration into the area of *Hexagenia* nymphs with a decrease in the chironomid popula-

tion. Considering Table III, we see that as the texture of the soil increases in fineness, with a corresponding increase in percentage of organic content, there is also an increase in the total population until the soil texture reaches the finest of the loam type. The loam type of soil has a total population of 5,543 which is 37 more than the clay-loam type. It appears after a certain number of chironomids (approximately 5,000 inhabit an area, the area must be considered a limiting factor if soil type and percentage of organic content are suitable.

TABLE III

THE AVERAGE PERCENT OF ORGANIC CONTENT AND TOTAL POPULATION OF EACH SOIL TYPE

Soil Type	Percent Organic Content	Chironomids
Sand	0.22	867
Sandy-loam	1.03	3,024
Sandy-clay	1.74	3,875
Silt-loam	1.40	1,727
Loam	2.19	5,543
Clay-loam	2.41	5,406

CONCLUSIONS

Soil type is a factor in the abundance of chironomids.

The pH is not a factor in the fresh water streams studied.

There were very few available nitrates in the soil.

The texture of the soil is important as a factor in the abundance of chironomids.

The organic matter content is also an important factor.

Area may be a limiting factor when soil texture and organic matter content are not.

This study shows that soil texture and organic matter content as well as area are important enough to warrant further study.

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ADDITIONS TO THE REVISED CATALOGUE OF OHIO VASCULAR PLANTS. VIII*

CLYDE H. JONES

Since the report of a year ago on the additions to the Ohio State Herbarium, we have received a collection of approximately 375 vascular plants, collected and identified in 1840 by the eminent Ohio botanist, William S. Sullivant. This excellently prepared and preserved collection is very valuable from a historical point of view, since many of the plants have not been collected in the state since that time. This probably indicates that these plants have been destroyed by farming, grazing, fire, disease, or insects.

During the past year we have been very fortunate in securing the technical advise of a number of taxonomists who are specialists in some of the more difficult groups. Numerous changes in the nomenclature and identification will be noted in this year's list.

The amateur botanists throughout the state have contributed their usual large number of interesting and valuable plant finds. One of the outstanding collections of the year is a collection of 1485 specimens donated by Robert and William Goslin. These plants were collected in Fairfield County, and although this county has been one of the favorite collecting grounds of Ohio botanists for the past one hundred years, many new and interesting distribution records are coming to light. Another carefully prepared and identified collection, consisting of 586 specimens, was donated by Don M. Brown. These plants were collected in Stark and neighboring counties, and although the collection has not been checked in its entirety, it promises to be one of great value, since most of the plants were collected near the northern boundary of the unglaciated plateau region of the state where very little collecting has been done in the past. Another valuable collection of plants from the sand dune, fossil beach, prairie, and swamp forest complex of Wood and Henry Counties was donated by R. E. Shanks. This collection has contributed a number of new and interesting range extensions.

An entire new set of species distribution maps of the vascular

flora of Ohio has just been completed, and investigators can now ascertain distribution records without direct examination of the harbarium specimens. A loose-leaf index of all of the reported Ohio species accompanies this set of maps.

A series of twelve papers, dealing with Ohio floristics, is in the process of preparation, and with their completion our knowledge of the distribution of vegetation in the various physiographic regions and ecological habitats of the state should be much more complete.

The following list of additions represent new county or state records, or distribution changes resulting from critical determinations and nomenclatorial changes.

1.1. *Botrychium engelmanni* Prantl. Engelmann's Addertongue. Minera Springs, E. Lucy Braun. 1932. Lynx Prairie, Robert B. Gordon. 1935. Buzzard's Roost, Clyde H. Jones. 1937. All stations are in Adams County.

5. *Botrychium obliquum* Muhl. Oblique Grape-fern. Damascus Twp., Henry Co. R. E. Shanks.

6. *Botrychium dissectum* Spreng. Cutleaf Grape-fern. Washington Twp., Henry Co. R. E. Shanks.

7. *Botrychium virginianum* (L.) Sw. Virginia Grape-fern. Damascus Twp., Henry Co. R. E. Shanks.

14. *Phegopteris hexagonoptera* (Mx.) Fee. Broad Beech-fern. Damascus Twp., Henry Co., and Freedom Twp., Wood Co. R. E. Shanks.

16. *Adiantum pedatum* L. Maidenhair-fern. Henry Twp., Wood Co. R. E. Shanks.

17. *Pteris aquilina* L. Common Bracken. Burton, Geauga Co. C. A. Dambach.

25a. Change to *Asplenosorus ebenoides* Wherry. We do not have a specimen of this interesting hybrid in the State Herbarium. It is reported to have been collected in Hocking County a number of years ago and from Washinton and Lawrence Counties during the past year. Collectors in the plateau counties should be on the lookout for this fern wherever the parents, *Asplenium platyneuron* and *Camptosorus rhizophyllus*, occur in close proximity.

30. *Athyrium angustum* (Willd.) Presl. Upland Lady-fern. Damascus Twp., Henry Co., and Henry Twp., Wood Co. R. E. Shanks.

32. *Camptosorus rhizophyllus* (L.) Link. Walking-fern. Wayne Twp., Tuscarawas Co. Don M. Brown. Athens Co. Bessie B. Bodle.

33. *Dryopteris noveboracensis* (L.) Gr. New York Shield-fern. Damascus Twp., Henry Co. R. E. Shanks.

37. *Dryopteris goldiana* (Hook.) Gr. Goldie's Shield-fern. Wayne Twp., Tuscarawas Co. Don M. Brown. Zaleski, Vinton Co. Walter P. Porter. Brush Creek Twp., Highland Co. Katie M. Roads.

38. *Dryopteris marginalis* (L.) Gr. Marginal Shield-fern. Athens Co. Bessie B. Bodle.

40. *Dryopteris spinulosa* (Muell.) Ktz. Spinulose Shield-fern. Henry Twp., Wood Co. R. E. Shanks. Brush Creek Twp., Highland Co. Katie M. Roads.

42. *Polystichum acrostichoides* (Mx.) Schott. Christmas-fern. Brush Creek Twp. Highland Co. Katie M. Roads.

43. *Dennstaedtia punctilobula* (Mx.) Moore. Boulder-fern. Brown Twp., Carroll Co., and Jackson Twp., Stark Co. Don M. Brown.

45. *Cystopteris fragilis* (L.) Bernh. Fragil Bladder-fern. Henry Twp., Wood Co. R. E. Shanks.

46. *Woodsia obtusa* (Spreng.) Torr. Blunt-lobed Woodsia. Wayne Twp., Tuscarawas Co. Don M. Brown.
54. *Equisetum praealtum* Raf. Great Scouring-rush. Washington Twp., Henry Co. R. E. Shanks. Lawrence Twp., Tuscarawas Co. Don M. Brown.
61. *Equisetum arvense* L. Field Horsetail. Napoleon Twp., Henry Co. R. E. Shanks.

62. *Lycopodium selago*, var. *patens* (Beauv.) Desv. (*L. porophilum*, in part). Fir Club-moss. Portage, Tuscarawas, Licking, Hocking, Fairfield, Ross, Jackson, and Vinton Counties.
63. *Lycopodium lucidulum* Michx. Shining Club-moss. Lucas, Fulton, Allen, Wayne, Champaign, Ashtabula, Lake, Cuyahoga, Medina, Summit, Stark, Tuscarawas, Licking, Coshocton, Perry, Fairfield, Hocking, Ross, Meigs, and Jackson Counties.
63.1. *Lycopodium lucidulum*, var. *occidentale* (Clute.) Wilson. (*L. porophilum*, in part). Ashtabula, Portage, Fairfield, Hocking, Pike, and Jackson Counties.
64. *Lycopodium inundatum* L. Bog Club-moss. Lucas, Knox, Portage, Trumbull and Hocking Counties.
65. *Lycopodium clavatum* L. Common Club-moss. Ashtabula, Cuyahoga, Portage, Trumbull, Tuscarawas, Knox, Coshocton, Licking, Perry, and Hocking Counties.
65.1. *Lycopodium clavatum*, var. *megastachyon* Fernald & Bissell. Athens Co.
66. *Lycopodium obscurum* L. Tree Club-moss. Defiance, Lucas, Lake, Ashtabula, Trumbull, Medina, Portage, Holmes, Licking, Fairfield, Hocking and Jackson Counties.
66.1. *Lycopodium obscurum*, var. *dendroideum* Michx. Jackson Co.
67. *Lycopodium complanatum* L. Trailing Club-moss. Licking, Fairfield, Hocking and Jackson Counties.
67.1. *Lycopodium complanatum*, var. *flabelliforme* Fernald. Lucas, Lake, Cuyahoga, Geauga, Summit, Portage, Trumbull, Ashland, Stark, Columbiana, Knox, Coshocton, Tuscarawas, Carroll, Jefferson, Franklin, Muskingum, Belmont, Perry, Morgan, Noble, Washington, Ross, Vinton, Athens, Pike, Jackson, Meigs, Gallia and Lawrence Counties.
67.2 *Lycopodium tristachyum* Pursh. Ashtabula, Hocking and Jackson Counties. Lycopodium determinations by L. R. Wilson.

85. *Sagittaria rigida* Pursh. Sessile-fruited Arrow-head. Canton Twp., Stark Co. Don M. Brown.
94. *Potamogeton americanus* Cham. & Schl. Long-leaf Pondweed. Bethlehem Twp., Stark Co. Don M. Brown.
100. *Potamogeton praelongus* Wulf. White-stem Pondweed. Plain Twp., Stark Co. Don M. Brown.
101. *Potamogeton perfoliatus* L. Clasping-leaf Pondweed. Bethlehem Twp., Stark Co. Don M. Brown.
107.1. *Potamogeton diversifolius* Raf. Rafinesque's Pondweed. Hocking, Athens Co. Walter P. Porter.
110. *Potamogeton pectinatus* L. Fennel-leaf Pondweed. Plain Twp., Stark Co. Don M. Brown.
111. *Zannichellia palustris* L. Zannichellia. Jackson Twp., Stark Co. Don M. Brown.
115. *Nelumbo lutea* (Willd.) Pers. American Water-lotus. Lake Twp., Stark Co. Don M. Brown.
121. *Sparganium eurycarpum* Engelm. Broad-fruited Bur-reed. Hope, Vinton Co., and Buchtel, Athens Co. Walter P. Porter and P. S. Wamsley.
126. *Typha angustifolia* L. Narrow-leaf Cat-tail. Barberton, Summit Co. Don M. Brown.
131. *Arisaema dracontium* (L.) Schott. Green-dragon. Liberty Twp., Wood Co. R. E. Shanks.
140. *Scirpus lineatus* Mx. Reddish Bulrush. Montgomery Twp., Wood Co. R. E. Shanks.

146. *Scirpus validus* Vahl. Great Bulrush. Liberty Twp., Wood Co. R. E. Shanks.

156. Change *Eleocharis mutata* (L.) R. & S. to *E. quadrangulata* (Mx.) R. & S.
157. Change *Eleocharis acuminata* (Muhl.) Nees. to *E. compressa* Sull.
159. Change *Eleocharis tenuis* (Willd.) Schultes to *E. capitata* (L.) R. Br.
160. Change *Eleocharis intermedia* (Muhl.) Schultes to *E. reclinata* Kunth.
163. *Eleocharis engelmanni* Steud. No specimens.
164. *Eleocharis ovata* (Roth) R. & S. No specimens.
      Eleocharis determinations by Ruth Lois Krehl.

166. *Stenophyllus capillaris* (L.) Britt. Hair-like Stenophyllus. Neotoma, Hocking Co. Edward S. Thomas.
168. *Cyperus strigosus* L. Straw-colored Cyperus. Hocking Twp., Fairfield Co. Robert Goslin. Chestnut Ridge, Sandusky Co., and Liberty Twp., Henry Co. R. E. Shanks.
170. *Cyperus filiculmis* Vahl. Slender Cyperus. Greenfield Twp., Fairfield Co. Robert Goslin.
173. *Cyperus engelmanni* Steud. Engelmann's Cyperus. Henry Twp., Wood Co. R. E. Shanks.
175. *Cyperus erythrorhizos* Muhl. Red-rooted Cyperus. Liberty Twp., Henry Co. R. E. Shanks.
189. *Scleria triglomerata* Mx. Tall Nut-rush. Oak Openings, Lucas Co. Floyd Bartley and Leslie L. Pontius.
196. *Carex convoluta* Mack. Convolute Sedge. Greenfield Twp., Fairfield Co. Robert Goslin.
202. *Carex lavenworthii* Dew. Leavenworth's Sedge. Bern Twp., Fairfield Co. Robert Goslin.
206. *Carex sparganioides* Muhl. Bur-reed Sedge. Richfield Twp., Henry Co., and Henry Twp., Wood Co. R. E. Shanks.
208. *Carex vulpinoidea* Mx. Fox Sedge. Berne Twp., Fairfield Co. Robert Goslin.
209. *Carex annectens* Bickn. Yellow Fox Sedge. Pleasant Twp., Fairfield Co. Robert Goslin.
215. *Carex laevi-vaginata* (Keuk.) Mack. Lancaster, Fairfield Co. William Goslin.
217. *Carex trisperma* Dew. Three-fruited Sedge. Greenfield Twp., Fairfield Co. Robert Goslin.
221. *Carex bromoides* Schk. Brome-like Sedge. Berne Twp., Fairfield Co. Robert Goslin.
233. *Carex straminea* Willd. Straw Sedge. Berne Twp., Fairfield Co. Robert Goslin.
247. *Carex emoryi* Dew. Emory's Sedge. Berne Twp., Fairfield Co. Charles and Robert Goslin.
253. *Carex durifolia* Bail. Back's Sedge. Silica Hollow, Hocking Co., and Waterloo Twp., Athens Co. Floyd Bartley and Leslie L. Pontius.
256. *Carex pennsylvanica* Lam. Pennsylvania Sedge. Berne Twp., Fairfield Co. William Goslin.
257. *Carex varia* Muhl. Emmon's Sedge. Waterloo Twp., Athens Co. Walter P. Porter. Pleasant Twp., Fairfield Co. Robert Goslin.
258. *Carex hirtifolia* Mack. Pubescent Sedge. Lancaster, Fairfield Co. Robert Goslin.
270. *Carex albursina* Sheld. White Bear Sedge. Greenfield Twp., Fairfield Co. Robert Goslin.
276. *Carex granularis* Muhl. Meadow Sedge. Lancaster, Fairfield Co. William Goslin.
289. *Carex swanii* (Fern.) Mack. Swan's Sedge. Greenfield Twp., Fairfield Co. Robert Goslin.
297. *Carex shortiana* Dew. Short's Sedge. Berne Twp., Fairfield Co. Robert Goslin.
317. *Carex frankii* Kunth. Frank's Sedge. Henry Twp., Wood Co. R. E. Shanks.

318. *Carex squarrosa* L. Squarrose Sedge. Washington Twp., Henry Co., and Henry Twp., Wood Co. R. E. Shanks.
321. *Carex asa-grayi* Bail. Gray's Sedge. Freedom Twp., Wood Co. R. E. Shanks.
323. *Carex lupulina* Muhl. Hop Sedge. Harrison Twp., Henry Co., and Montgomery Twp., Wood Co. R. E. Shanks.
329. *Bromus racemosus* L. Upright Chess. Berne Twp., Fairfield Co. Robert Goslin.
334. *Bromus purgans* L. Hairy Brome-grass. Lawrence Twp., Tuscarawas Co. Don M. Brown.
335. *Bromus tectorum* L. Downy Brome-grass. Hocking Twp., Fairfield Co. Robert Goslin.
342. *Festuca ovina* L. Sheep Fescue-grass. Hocking Twp., Fairfield Co. Robert Goslin.
344. *Festuca octoflora* Walt. Slender Fescue-grass. Jackson Twp., Stark Co. Don M. Brown.
350. *Panicularia nervata* (Willd.) Ktz. Nerved Mann-grass. Pike Twp., Stark Co. Don M. Brown.
361. *Poa triflora* Gilib. Fowl Meadow-grass. Plain Twp., Stark Co. Don M. Brown.
362. *Poa pratensis* L. Kentucky Blue-grass. Berne Twp., Fairfield Co. Robert Goslin.
365. *Dactylis glomerata* L. Orchard-grass. Berne Twp., Fairfield Co. Robert Goslin.
368. *Eragrostis major* Host. Strong-scented Love-grass. Liberty Twp., Wood Co. R. E. Shanks. Canton, Stark Co. Don M. Brown.
370. *Eragrostis purshii* Schrad. Pursh's Love-grass. Canton, Stark Co. Don M. Brown.
371. *Eragrostis pilosa* (L.) Beauv. Tufted Love-grass. Lancaster, Fairfield Co. Robert and William Goslin.
373. *Eragrostis capillaris* (L.) Ness. Capillary Love-grass. Lancaster, Fairfield Co. Robert Goslin. Athens Co. Len Stephenson.
385. *Arrhenatherum elatius* (L.) Beauv. Oat-grass. Hocking Twp., Fairfield Co. Robert Goslin.
386. *Trisetum pennsylvanicum* (L.) Beauv. Marsh False-oats. Greenfield Twp., Fairfield Co. Robert Goslin.
395. *Sporobolus vaginaeflorus* Torr. Sheathed Rush-grass. Lancaster, Fairfield Co. Robert Goslin.
404. *Agrostis alba* L. Red-top Bent-grass. Greenfield Twp., Fairfield Co. Robert Goslin. Hillsboro, Highland Co. Katie M. Roads.
407. *Agrostis hyemalis* (Walt.) B. S. P. Rough Bent-grass. Canton, Stark Co. Don M. Brown.
409. *Cinna arundinacea* L. Wood Reed-grass. Montgomery Twp., Wood Co. R. E. Shanks.
417. *Muhlenbergia mexicana* (L.) Trin. Mexican Muhlenbergia. Lancaster, Fairfield Co. Robert Goslin.
418. *Muhlenbergia racemosa* (Mx.) B. S. P. Marsh Muhlenbergia. Jackson Twp., Stark Co. Don M. Brown.
421. *Muhlenbergia schreberi* Gmel. Spreading Muhlenbergia. Liberty Twp., Wood Co. R. E. Shanks. Lancaster, Fairfield Co. Robert Goslin.
422. *Brachyelytrum erectum* (Schreb.) Beauv. Brachyelytrum. Wayne Twp., Tuscarawas Co. Don M. Brown.
423. *Millium effusum* L. Tall Millet-grass. Lawrence Twp., Tuscarawas Co. Don M. Brown.
427. *Aristida dichotoma* Mx. Poverty-grass. Neotoma, Hocking Co. Edward S. Thomas.
433. *Phlalaris arundinacea* L. Reed Canary-grass. Liberty Twp., Wood Co. R. E. Shanks.
435. *Anthoxanthum odoratum* L. Sweet Vernal-grass. Lawrence Twp., Tuscarawas Co. Don M. Brown.
438. *Lolium multiflorum* Lam. Awned Darnel. Canton, Stark Co. Don M. Brown.

439. *Agropyron repens* (L.) Beauv. Couch-grass. Plain Twp., Stark Co. Don M. Brown. Lancaster, Fairfield Co. Robert Goslin.
440. *Agropyron smithii* Rydb. Western Wheat-grass. Introduced along railway tracks near Canton, Stark Co. Don M. Brown.
452. *Hordeum jubatum* L. Squirrel-tail Barley. Sugar Creek Twp., Stark Co. Don M. Brown. Lancaster, Fairfield Co. Robert Goslin.
460. *Homalocenchrus virginicus* (Willd.) Britt. Virginia Cut-grass Berne Twp., Fairfield Co. Robert Goslin. Richfield Twp., Henry Co. R. E. Shanks.
461. *Homalocenchrus oryzoides* (L.) Poll. Rice Cut-grass. Canton Twp., Stark Co. Don M. Brown.
463. *Zizania aquatica* L. Wild-rice. Summit Co. Don M.. Brown.
466. *Panicum virgatum* L. Tall Smooth Panic-grass. Canton Twp., Stark Co. Don M. Brown.
467. *Panicum dichotomiflorum* Mx. Spreading Panic-grass. Richfield Twp., Henry Co. R. E. Shanks. Berne Twp., Fairfield Co. Robert Goslin.
473. *Panicum gattingeri* Nash. Gattinger's Panic-grass. Lancaster, Fairfield Co. Robert Goslin.
479. *Panicum linearifolium* Scribn. Linear-leaf Panic-grass. Pleasant Twp., Fairfield Co. Robert Goslin.
488. *Panicum lindheimeri* Nash. Lindheimer's Panic-grass. Adams Co. Floyd Bartley and Leslie L. Pontius.
496. *Panicum clandestinum* L. Hispid Panic-grass. Harrison Twp., Henry Co. R. E. Shanks.
497. *Panicum latifolium* L. Broad-leaf Panic-grass. Liberty Twp., Wood Co. R. E. Shanks.
498. *Panicum boscii* Poir. Bosc's Panic-grass. Liberty Twp., Wood Co. R. E. Shanks.
499. *Leptoloma cognatum* (Schultes) Chase. Fall Witch-grass. Penn Twp., Highland Co. Katie M. Roads.
500. *Syntherisma filiforme* (L.) Nash. Slender Crab-grass. Neotoma, Hocking Co. Edward S. Thomas.
501. *Syntherisma ischaemum* (Schreb.) Nash. Small Crab-grass. Pike Twp., Stark Co. Don M. Brown.
508. *Paspalum setaceum* Mx. Slender Paspalum. Berne Twp., Fairfield Co. Robert Goslin.
509. *Chaetochloa verticillata* (L.) Scribn. Verticillate Foxtail-grass. Lancaster, Fairfield Co. Robert Goslin.
513. *Cenchrus pauciflorus* Benth. Sandbur-grass. Lancaster, Fairfield Co. Robert and William Goslin.
516. *Sorghastrum nutans* (L.) Nash. Indian-grass. Berne Twp., Robert, William and Charles Goslin.
519. *Andropogon furcatus* Muhl. Big Bluestem. New Vienna, Clinton Co. Katie M. Roads. Sandy Twp., Stark Co. Don M. Brown.
522. *Andropogon scoparius* Mx. Little Bluestem. Jackson Twp., Stark Co. Don M. Brown.
527. *Lilium canadense* L. Canada Lily. Berne Twp., Fairfield Co. Robert and William Goslin. Pike Twp., Stark Co. Don M. Brown. Burton, Geauga Co. C. A. Dambach.
531. *Erythronium albidum* Nutt. White Dog-tooth Lily. Lawrence Twp., Tuscarawas Co. Don M. Brown.
534. *Allium tricoccum* Ait. Wild Leek. Sugarcreek Twp., Stark Co. Don M. Brown. Brush Creek Twp., Highland Co. Katie M. Roads.
535.1. *Allium sativum* L. European Garlic. New Vienna, Clinton Co. Katie M. Roads.
541. *Quamasia hyacinthina* (Raf.) Britt. Wild Hyacinth. Sugarcreek Twp., Stark Co. Don M. Brown.
551. *Anticlea elegans* (Pursh.) Rydb. Glaucous Anticlea. New Moorefield, Clark Co. C. A. Dambach.
552. *Stenanthium robustum* Wats. Stout Stenanthium. Pike Twp., Stark Co. Don M. Brown.
554. *Triantha glutinosa* (Mx.) Baker. Glutinous Triantha. New Moorefield, Clark Co. C. A. Dambach.

562. *Medeola virginiana* L. Indian Cucumber-root. Liberty Twp., Wood Co. R. E. Shanks. Burton, Geauga Co. C. A. Dambach.

567. *Disporum lanuginosum* (Mx.) Nich. Hairy Disporum. Greenfield Twp., Fairfield Co. Robert Goslin. Osnaburg Twp., Stark Co. Don M. Brown.

571. *Vagnera racemosa* (L.) Mor. Panicled False Solomon's-seal. Burton, Geauga Co. C. A. Dambach.

572. *Vagnera stellata* (L.) Mor. Stellate False Solomon's-seal. Jackson Twp., Stark Co. Don M. Brown.

584. *Smilax rotundifolia* L. Round-leaf Greenbriar. Wayne Twp., Tuscarawas Co. Don M. Brown.

593. *Juncus effusus* L. Common Rush. Montgomery Twp., Wood Co. R. E. Shanks.

596. *Juncus dudleyi* Wieg. Dudley's Rush. Berne Twp., Fairfield Co. Robert Goslin.

597. *Juncus tenuis* Willd. Slender Rush. Neotoma, Hocking Co. Edward S. Thomas.

617. *Hypoxis hirsuta* (L.) Cov. Yellow Stargrass. Brown Twp., Carroll Co. Don M. Brown.

627. *Iris versicolor* L. Northern Blue-flag. Hooker, Fairfield Co. William Goslin. Also Waynesburg, Carroll Co., and Barberton, Summit Co. Don M. Brown.

644. *Lysias orbiculata* (Pursh.) Rydb. Large Round-leaf Orchis. Brown Twp., Carroll Co. Don M. Brown.

648. *Blephariglottis lacera* (Mx.) Farw. Ragged Fringed-orchis. Burton, Geauga Co. C. A. Dambach.

652. *Blephariglottis psycodes* (L.) Rydb. Smaller Purple Fringed-orchis. Oak Openings, Lucas Co. Floyd Bartley and Leslie L. Pontius.

658. *Ibidium gracile* (Bigel.) House. Slender Lady's-tresses. Mill Twp., Tuscarawas Co. Irma Nelson.

666. *Malaxis unifolia* Mx. Green Adder-mouth. Vinton Co. Floyd Bartley and Leslie L. Pontius.

667. *Liparis liliifolia* (L.) Rich. Large Twayblade. Mill Twp., Tuscarawas Co. Irma Nelson. Brown Twp., Carroll Co. Don M. Brown.

672. *Corallorrhiza maculata* Raf. Large Coral-root. Rock Run, Jackson Co. Floyd Bartley and Leslie L. Pontius.

679. *Liriodendron tulipifera* L. Tuliptree. Damascus Twp., Henry Co. R. E. Shanks.

680. *Asimina triloba* (L.) Dunal. Papaw. Damascus Twp., Henry Co. R. E. Shanks.

682.1. *Ranunculus alleghaniensis* Britt. Mountain Crow-foot. Hope, Vinton Co. Walter P. Porter.

691. *Ranunculus fascicularis* Muhl. Tufted Buttercup. Twerton Twp., Coshocton Co. Floyd Von Ohlen.

706. *Delphinium tricorne* Mx. Dwarf Larkspur. Fairfield Twp., Tuscarawas Co. Don M. Brown.

740. *Benzoin aestivale* (L.) Nees. Spicebush. Montgomery Twp., Wood Co. R. E. Shanks.

764.1. *Lesquerella globosa* (Desv.) S. Wats. Short's Bladder-pod. Vinton Co. Len Stephenson.

769. *Camelina sativa* (L.) Crantz. Common False-flax. Berne Twp., Fairfield Co. Robert Goslin.

770. *Camelina microcarpa* Andrz. Small-fruited False-flax. Jackson Twp., Stark Co. Don M. Brown.

779. *Lepidium campestre* (L.) R. Br. Field Peppergrass. Hocking Twp., Fairfield Co. William Goslin.

786. *Thlaspi arvense* L. Field Penny-cress. Berne Twp., Fairfield Co. Robert Goslin.

791. *Sophia incisa* (Engelm.) Greene. Western Tansy-mustard. Berne Twp., Fairfield Co. Robert and William Goslin.

821. *Cardamine pennsylvanica* Muhl. Pennsylvania Bitter-cress. Berne Twp., Fairfield Co. Robert Goslin.

827. *Dentaria heterophylla* Nutt. Slender Toothwort. Berne Twp., Fairfield Co. William Goslin.
828. *Dentaria multifida* Muhl. Multifid Toothwort. Lodi Twp., Athens Co. Walter P. Porter.
853. *Geranium pusillum* L. Small-flowered Crane's-bill. Lawrence Twp., Tuscarawas Co. Don M. Brown.
862. *Oxalis violacea* L. Violet Wood-sorrel. Brown Twp., Carroll Co. Don M. Brown.
872. *Floerkea proserpinacoides* Willd. False-mermaid. Pleasant Twp., Fairfield Co. Robert Goslin. Lodi Twp., Athens Co. Walter P. Porter.
876. *Zanthoxylum americanum* Mill. Prickly-ash. Sugar Creek Twp., Stark Co. Don M. Brown.
877. *Ptelea trifoliata* L. Hop-tree. Sandy Twp., Tusacrawas Co. Don M. Brown. Troy Twp., Wood Co. R. E. Shanks.
883. *Polygala incarnata* L. Pink Milkwort. Madison Twp., Fairfield Co. Helen and Jean Rea.
892. *Croton monanthogynus* Mx. Single-fruited Croton. Canaan Twp., Athens Co. Warren Abbott.
895. *Poinsettia dentata* (Mx.) Small. Toothed Spurge. Bellefontaine, Logan Co. A. G. Welshimer.
898. *Tithymalus platyphyllus* (L.) Hill. Broadleaf Spurge. Maumee, Lucas Co. Chas. C. Deam.
903. *Tithymalus peplus* (L.) Hill. Petty Spurge. Hillsboro, Highland Co. Katie M. Roads.
905. *Tithymalopsis corollata* (L.) Kl. and Garcke. Flowering Spurge. Washington Twp., Henry Co. R. E. Shanks.
915. *Callitriche austini* Engelm. Terrestrial Water-starwort. Scioto Twp., Ross Co. Edward S. Thomas, Joe Enke and J. S. Thomas.
925. *Napaea dioica* L. Glade Mallow. Dover Twp., Tuscarawas Co. Clyde H. Jones.
931. *Hibiscus trionum* L. Bladder Ketmia. Athens, Athens Co. Flora E. Hall.
937. *Hypericum prolificum* L. Shrubby St. John's-wort. Burton, Geauga Co. C. A. Dambach.
939. *Hypericum perforatum* L. Common St. John's-wort. Zane Twp., Logan Co. A. G. Welsheimer. Henry Twp., Wood Co. R. E. Shanks.
944. *Hypericum mutilum* L. Small-flowered St. John's-wort. Washington Twp., Highland Co. Katie M. Roads. Damascus Twp., Henry Co. R. E. Shanks.
950. *Triadenum virginicum* (L.) Raf. Marsh St. John's-wort. Sandy Twp., Stark Co. Don M. Brown.
952. *Crocanthemum majus* (L.) Britt. Hoary Frostweed. Plain Twp., Wood Co. R. E. Shanks.
956. *Lechea racemulosa* Lam. Oblong-fruited Pinweed. Mill Twp., Tuscarawas Co. Irma Nelson.
962. *Cubelium concolor* (Forst.) Raf. Green Violet. Dover Twp., Tuscarawas Co. Irma Nelson.
964. *Viola eriocarpa* Schw. Smooth Yellow Violet. Athens Twp., Athens Co. Warren Abbott.
967. *Viola striata* Ait. Striped Violet. Brown Twp., Carroll Co. Don M. Brown. Dover Twp., Tuscarawas Co. Irma Nelson.
970. *Viola rostrata* Pursh. Long-spurred Violet. Plain Twp., Stark Co. Don M. Brown. Dover Twp., Tuscarawas Co. Irma Nelson.
971. *Viola rafinesquii* Greene. Wild Pansy. Alexander Twp., Athens Co. Harold H. Moore.
971.1. *Viola arvensis* Murr. Field Pansy. Lawrence Twp., Tuscarawas Co. Don M. Brown.
975. *Viola blanda* Willd. Sweet White Violet. Athens Twp., Athens Co. Warren Abbott.
976. *Viola pallens* (Banks) Brain. Woodland White Violet. Plain Twp., Stark Co. Don M. Brown.
980. *Viola papilionacea* Pursh. Common Blue Violet. Canton, Stark Co. Don M. Brown.

981. *Viola sororia* Willd. Woolly Blue Violet. Loudonville, Ashland Co. Don M. Brown.
994. *Viola palmata* L. Early Blue Violet. Athens Twp., Athens Co. Warren Abbott.
987. *Viola fimbriatula* Sm. Ovate-leaf Violet. Sandy Twp., Stark Co. Rose Twp., Carroll Co. Don M. Brown. Red Hills, Franklin Co. C. A. Dambach.
988. *Viola sagittata* Ait. Arrow-leaf Violet. Plain Twp., Stark Co. Don M. Brown. The Plains, Athens Co. Walter P. Porter.
990. *Passiflora incarnata* L. Purple Passion-flower. Escaped from cultivation on North Hill, Athens, Athens Co. Warren Abbott.
1001. *Alsine media* L. Common Chickweed. Lawrence Twp., Tuscarawas Co. Don M. Brown.
1003. *Alsine longifolia* (Muhl.) Britt. Longleaf Stitchwort. Berne Twp., Fairfield Co. Robert Goslin.
1104. *Alsine graminea* (L.) Britt. Lesser Stitchwort. Hospital Grounds, Athens, Athens Co. Walter P. Porter and P. S. Wamsley.
1005. *Cerastium vulgatum* L. Common Mouse-ear Chickweed. Pleasant Twp., Fairfield Co. Robert Goslin. Athens, Athens Co. Warren Abbott.
1006. *Cerastium viscosum* L. Mouse-ear Chickweed. Conkle's Hollow, Hocking Co. Edward S. Thomas and A. R. Harper. Athens Twp., Athens Co. Warren Abbott.
1013. *Agrostemma githago* L. Corn Cockle. Burton, Geauga Co. C. A. Dambach.
1015. *Lychnis alba* Mill. White Lychnis. Willowdale Lake, Stark Co. Don M. Brown.
1020. *Silene latifolia* (Mill.) Britt. & Rend. Bladder Campion. Brown Twp., Carroll Co. Don. M. Brown. Mantua Twp., Portage Co. C. A. Dambach.
1026. *Silene virginica* L. Fire Pink. Athens Twp., Athens Co. Warren Abbott. Liberty Twp., Wood Co. R. E. Shanks.
1031. *Silene antirrhina* L. Sleepy Catchfly. Liberty Twp., Wood Co. R. E. Shanks.
1038. *Claytonia virginica* L. Spring-beauty. Lawrence Twp., Tuscarawas Co. Don M. Brown.
1042. *Mollugo verticillata* L. Carpetweed. Liberty Twp., Wood Co. R. E. Shanks.
1047. *Anychia polygonoides* Raf. Forked Anychia. Pike Twp., Stark Co. Don M. Brown.
1048. *Anychia canadensis* (L.) B. S. P. Slender Anychia. Liberty Twp., Wood Co. R. E. Shanks.
1052. *Amaranthus hybridus* L. Slender Pigweed. Liberty Twp., Wood Co. R. E. Shanks.
1054. *Amaranthus graecizans* L. Tumble-weed. Willowdale Lake, Stark Co. Don M. Brown.
1056. *Acnida tuberculata* Moq. Tubercled Water-hemp. Berne Twp., Fairfield Co. Robert and William Goslin.
1068. *Chenopodium botrys* L. Feather-geranium. Barberton, Summit Co. Don M. Brown.
1081. *Steironema lanceolatum* (Walt.) Gr. Lanceleaf Yellow Loosestrife. Hocking Twp., Fairfield Co. William Goslin.
1085. *Lysimachia nummularia* L. Moneywort. Berne Twp., Fairfield Co. William Goslin. Burton, Geauga Co. C. A. Dambach.
1094. *Rumex verticillatus* L. Swamp Dock. Burton, Geauga Co. C. A. Dambach.
1095. *Rumex altissimus* Wood. Tall Dock. Berne Twp., Fairfield Co. Robert and William Goslin.
1098. *Rumex britannica* L. Great Water Dock. Willowdale Lake, Stark Co. Don M. Brown.
1106. *Tiniaria dumetorum* (L.) Opiz. Copse False Buckwheat. Canaan Twp., Athens Co. Warren Abbott.
1109. *Tracaulon arifolium* (L.) Raf. Halberd-leaf Tear-thumb. Berne Twp., Fairfield Co. Robert Goslin.
1113. *Persicaria hydropiperoides* (Mx.) Small. Mild Smartweed. Henry Twp., Wood Co. R. E. Shanks.

1118. *Persicaria muhlenbergii* (Wats.) Small. Swamp Persicaria. Berne Twp., Fairfield Co. Robert and William Goslin.

1128. *Geum vernum* (Raf.) T. & G. Spring Avens. Liberty Twp., Wood Co. R. E. Shanks.

1129. *Geum canadense* Jacq. White Avens. Berne Twp., Fairfield Co. William Goslin. Liberty Twp., Wood Co. R. E. Shanks.

1131. *Geum flavum* (Port.) Bickn. Cream-colored Avens. Athens Co. Floyd Bartley and Leslie L. Pontius.

1138. *Potentilla canadensis* L. Common Five-finger. Burton, Geauga Co. C. A. Dambach.

1143. *Drymocallis agrimonioides* (Pursh.) Rydb. Tall Cinquefoil. Isaac Walton Farm, Athens Co. Walter P. Porter.

1144.1. *Duchesnea indica* (Andr.) Fooke. Indian Strawberry. Athens Co. Warren Abbott.

1149. *Rubus phoenicolasius* Max. Wineberry. Salem Twp., Meigs Co. Clyde H. Jones.

1151. *Ribus strigosus* Mx. Wild Red Raspberry. Salem Twp., Meigs Co. Clyde H. Jones.

1153. *Rubus laciniatus* Willd. Cutleaf Blackberry. Champaign Co. Margaret B. Church.

1159. *Porteranthus trifoliatus* (L.) Britt. Indian-physic. O. S. U. Botanical Garden. Introduced with Rhododendron clumps from the Great Smokies. Clyde H. Jones.

1162. *Filipendula rubra* (Hill.) Rob. Queen-of-the-prairie. The Plains, Athens Co. Walter P. Porter.

1164. *Opulaster opulifolius* (L.) Ktz. Ninebark. Monroe Twp., Henry Co. R. E. Shanks. Berne Twp., Fairfield Co. Robert Goslin.

1168. *Aruncus sylvester* Kost. Aruncus. Fairfield Co. William Goslin.

1171. *Rosa rubiginosa* L. Sweetbriar. Liberty Twp., Wood Co. R. E. Shanks.

1178. *Rosa virginiana* Mill. Virginia Rose. Liberty Twp., Wood Co. R. E. Shanks.

1180. *Agrimonia rostellata* Wallr. Woodland Agrimony. Lawrence Twp., Tuscarawas Co. Don M. Brown.

1183. *Agrimonia gryposepala* Wallr. Hairy Agrimony. Berne Twp., Fairfield Co. William Goslin.

1207. *Amelanchier sanguinea* (Pursh.) DC. Roundleaf Juneberry. Good Hope Twp., Hocking Co. Edward S. Thomas.

1234. *Cassia marilandica* L. Wild Senna. Hocking Co. Warren Abbott.

1240. Change to 1240a. *Baptisia tinctoria crebra* Fernald. *B. tinctoria typica* is not known to occur in the state. Baptisia determinations by M. M. Larisey.

1248. *Trifolium agrarium* L. Yellow Hop Clover. Plain Twp., Stark Co. Don M. Brown.

1261. *Cracca virginiana* L. Virginia Goat's-rue. Mill Twp., Tuscarawas Co. Irma Nelson.

1269. *Psoralea onobrychis* Nutt. Sainfoin Psoralea. Fairfield Co. William Goslin.

1273. *Meibomia canescens* (L.) Ktz. Hoary Tick-trefoil. Berne Twp., Fairfield Co. William Goslin.

1276. *Meibomia michauxii* Vail. Prostrate Tick-trefoil. Newark Twp., Licking Co. Warren Abbott.

1284. *Meibomia sessilifolium* (Torr.) Ktz. Sessile-leaf Tick-trefoil. Oak Openings, Lucas Co. Floyd Bartley and Leslie L. Pontius.

1288. *Meibomia nudiflora* (L.) Ktz. Naked-flowered Tick-trefoil. Perry Twp., Tuscarawas Co. Irma Nelson.

1290. *Lespedeza capitata* Mx. Round-headed Bush-clover. Jackson Twp., Stark Co. Don M. Brown.

1296. *Lespedeza procumbens* Mx. Trailing Bush-clover. Athens Twp., Athens Co. Walter P. Porter. Wingfoot Lake, Portage Co. Don M. Brown.

1300. *Vicia cracca* L. Cow Vetch. Suffield, Portage Co. Don M. Brown.

1318. *Glycine apios* L. Groundnut. Berne Twp., Fairfield Co. Robert Goslin.

1331. *Penthorum sedoides* L. Ditch Stonecrop. Pleasant Twp., Henry Co. R. E. Shanks.

1332. *Micranthes virginiensis* (Mx.) Small. Early Saxifrage. Wayne Twp., Tuscarawas Co. Don M. Brown. Athens, Athens Co. Warren Abbott.

1333. *Micranthes pennsylvanica* (L.) Haw. Pennsylvania Saxifrage. The Plains,
Athens Co. Walter P. Porter and P. S. Wamsley.
1335. *Tiarella cordifolia* L. False Miterwort. Athens, Athens Co. Warren Abbott.
1336. *Heuchera americana* L. Common Alum-root. Liberty Twp., Wood Co.
R. E. Shanks.
1346. *Lythrum alatum* Pursh. Wing-angled Loosestrife. Licking Co. Warren
Abbott. Berne Twp., Fairfield Co. Robert and William Goslin. Liberty
Twp., Wood Co. R. E. Shanks.
1353. *Rhamnus frangula* L. Black Buckthorn. Canton Twp., Stark Co. Don M.
Brown.

1359. *Vitis labrusca* L. Northern Fox Grape. Lorain and Jackson Counties.
1359.1. *Vitis labruscana* Bail. Ashtabula County.
1360. *Vitis aestivalis* Mx. Summer Grape. Auglaize, Medina, Summit, Monroe,
Jackson and Lawrence Counties.
1360.1. *Vitis aestivalis*, form *argenifolia* (Muns.) Fernald. General in the plateau
counties of the state.
1361. *Vitis cinera* Engelm. Ashy Grape. Brown, Scioto, and Meigs Counties.
1362. *Vitis bicolor* LeC. Winter Grape. General in the plateau counties of the
state. Also Williams and Henry Counties.
1363. *Vitis vulpina* L. Riverside Grape. General.
1364. *Vitis cordifolia* Mx. Frost Grape. General.
Vitis determinations by R. W. Pohl.

1370. *Euonymus obovatus* Nutt. Running Strawberry-bush. Brown Twp., Carroll
Co. Don M. Brown.
1375. *Ilex verticillata* (L.) Rr. Winterberry. Wayne Twp., Tuscarawas Co. Don
M. Brown. The Plains, Athens Co. Walter P. Porter. Liberty Twp.,
Wood Co. R. E. Shanks. Berne Twp., Fairfield Co. Robert Goslin.
1376. *Staphylea trifolia* L. American Bladdernut. Berne Twp., Fairfield Co.
William Goslin. Henry Twp., Wood Co. R. E. Shanks.
1381. *Acer nigrum* Mx. Black Maple. Troy Twp., Wood Co. R. E. Shanks.
1382. *Acer saccharum* Marsh. Sugar Maple. Fairfield Twp., Tuscarawas Co. Don
M. Brown.
1389. *Rhus hirta* (L.) Sudw. Staghorn Sumac. Portage and Stark Counties. Don
M. Brown.
1391. *Schmaltzia crenata* (Mill.) Greene. Fragrant Sumac. Troy Twp., Wood Co.
R. E. Shanks.
1407. *Cannabis sativa* L. Hemp. Mad River Twp., Champaign Co. A. G.
Welshimer.
1411. *Urtica dioica* L. Stinging Nettle. Wingfoot Lake, Portage Co. Don M.
Brown.
1414. *Pilea pumila* (L.) Gr. Clearweed. Brush Creek Twp., Highland Co. Katie
M. Roads.
1415. *Boehmeria cylindrica* (L.) Sw. False Nettle. Plain Twp., Wood Co. R. E.
Shanks.
1416. *Parietaria pennsylvania* Muhl. Pennsylvania Pellitory. Troy Twp., Wood Co.
R. E. Shanks.
1421. *Quercus montana* Willd. Rock Chestnut Oak. Brush Creek Twp., Highland
Co. Katie M. Roads.
1423. *Quercus alba* L. White Oak. Waynesburg, Stark Co. Don M. Brown.
1425. *Quercus macrocarpa* Mx. Bur Oak. Plain Twp., Stark Co. Don M. Brown.
1426.1. *Quercus leana* Nutt. (*imbricaria* x *velutina*). Lea's Oak. Kettle Hills, Fair-
field Co. Clyde H. Jones.
1431 *Quercus coccinea* Wang. Scarlet Oak. Canton Twp., Stark Co. Don M.
Brown.
1432. *Quercus rubra* L. Red Oak. Liberty Twp., Wood Co. R. E. Shanks.
1434. *Carpinus caroliniana* Walt. Blue-beech. Lawrence Twp., Tuscarawas Co.
Don M. Brown.
1444. *Alnus vulgaris* Hill European Alder. Escaped from cultivation and grow-
ing at the mouth of Chagrin River, Lake Co. Don M. Brown.

1447. *Hicoria microcarpa* (Nutt.) Britt. Small-fruited Hickory. Montgomery Twp., Wood Co. R. E. Shanks.
1453. *Juglans cinera* L. Butternut. Troy Twp., Wood Co. R. E. Shanks.
1457. *Populus heterophylla* L. Swamp Poplar. Canton Twp., Stark Co. Don M. Brown.
1465. *Salix nigra* Marsh. Black Willow. Plain Twp., Stark Co. Don M. Brown.
1467. *Salix fragilis* L. Crack Willow. Richfield Twp., Henry Co. R. E. Shanks.
1471. *Salix babylonica* L. Weeping Willow. A dozen large trees in a swamp near Hillsboro, Highland Co. Katie M. Roads.
1472. *Salix interior* Row. Sandbar Willow. Montgomery Twp., Wood Co. R. E. Shanks.
1473a. *Salix glaucophylla albovestita* Ball. Erie Co.
1474. *Salix cordata* Muhl. Heartleaf Willow. Athens Twp., Athens Co. Harold H. Moore.
1475. *Salix adenophylla* Hook. is a northern species and is not known to occur in Ohio.
1476. *Salix pedicellaris* Pursh. Bog Willow. Jackson Twp., Stark Co. Don M. Brown.
1482. *Salix humulis* Marsh. Prairie Willow. Dover Twp., Tuscarawas Co. Don M. Brown. Washington Twp., Henry Co. R. E. Shanks.
1488. *Hydrangea arborescens* L. Wild Hydrangea. Wayne Twp., Tuscarawas Co. Don M. Brown.
1490. *Ribes americanum* Mill. Wild Black Currant. Berne Twp., Fairfield Co. Robert Goslin.
1499. *Ludwigia alternifolia* L. Seed-box. Jackson Twp., Stark Co. Don M. Brown.
· 1501. *Chamaenerion angustifolium* (L.) Scop. Fire-weed. Brown Twp., Carroll Co. Don M. Brown.
1503. *Epilobium strictum* Muhl. Downy Willow-herb. Jackson Twp., Stark Co. Don M. Brown.
1505. *Epilobium adenocaulon* Haussk. Northern Willow-herb. Berne Twp., Fairfield Co. William Goslin.
1509. *Kneiffia pratensis* Small. Meadow Sundrops. Wayne Twp., Tuscarawas Co. Don M. Brown.
1510. *Kneiffia pumila* (L.) Spach. Small Sundrops. Lawrence Twp., Tuscarawas Co. Don M. Brown.
1512. *Kneiffia fruticosa* (L.) Raim. Common Sundrops. Fairfield Co. William Goslin.
1516. *Gaura biennis* L. Biennial Gaura. Lawrence Twp., Tuscarawas Co. Don M. Brown.
1517. *Circaea lutetiana* L. Common Enchanter's-nightshade. Liberty Twp., Wood Co. R. E. Shanks.
1542. *Kalmia latifolia* L. Mountain Kalmia. Wayne Twp., Tuscarawas Co. Don ·M. Brown.
1543. *Epigaea repens* L. Trailing Arbutus. Sandy Twp., Stark Co. Don M. Brown.
1551. *Pyrola elliptica* Nutt. Shinleaf Wintergreen. Rush Twp., Tuscarawas Co. Irma Nelson. Berne Twp., Fairfield Co. William Goslin.
1558. *Polycodium stamineum* (L.) Greene. Deerberry. Fairfield Twp., Tuscarawas Co. Don M. Brown.
1567. *Gaylussacia baccata* (Wang.) Kock. Black Huckleberry. Washington Twp., Henry Co. R. E. Shanks.
1568. *Diospyros virginiana* L. Persimmon. Hocking Twp., Fairfield Co. William Goslin.
1571.1. *Polemonium reptans* L. var. *villosum* Braun. Hairy Greek Valerian. Segregated as a variety in 1939 by E. Lucy Braun from material collected in Adams Co. Examination of the Polemonium material in the State Herbarium yields specimens of this variety from the following counties: Scioto, Pike, Jackson, Lawrence, Montgomery, Mercer, and Darke.
1575. *Phlox paniculata* L. Garden Phlox. (Albino form). Zaleski, Vinton Co. Walter P. Porter.
1589. *Convolvus spithamaeus* L. Upright Bindweed. Mill Twp., Tuscarawas Co. Irma Nelson.

1606. *Phacelia purshii* Buckl. Pursh's Phacelia. Millville Twp., Butler Co. C. A. Dambach.

1615. *Fraxinus quadrangulata* Mx. Blue Ash. Marion Twp., Henry Co. Troy Twp., Wood Co. R. E. Shanks.

1628. *Gentiana andrewsii* Griseb. Closed Gentian. Harrison Twp., Henry Co. R. E. Shanks.

1632. *Bartonia virginica* (L.) B. S. P. Yellow Bartonia. Oak Openings. Lucas Co. Floyd Bartley and Leslie L. Pontius.

1636. *Apocynum androsaemifolium* L. Spreading Dogbane. Plain Twp., Wood Co. R. E. Shanks. Burton, Geauga Co. C. A. Dambach.

1637. *Apocynum medium* Greene. Intermediate Dogbane. Union Twp., Logan Co. A. G. Welshimer.

1638. *Apocynum cannabinum* L. Indian-hemp. Union Twp., Logan Co. A. G. Welshimer.

1641. *Asclepiodora viridis* (Walt.) Gr. Oblong-leaf Green Milkweed. Scioto Twp., Ross Co. Edward S. Thomas.

1642. *Acerates viridiflora* (Raf.) Eat. Green Milkweed. Union Twp., Logan Co. A. G. Welshimer.

1645. *Asclepias purpurascens* L. Purple Milkweed. Champaign Co. Margaret B. Church.

1646. *Asclepias incarnata* L. Swamp Milkweed. Plain Twp., Wood Co. R. E. Shanks.

1653. *Asclepias quadrifolia* Jacq. Fourleaf Milkweed. Mill Twp., Tuscarawas Co. Irma Nelson and R. C. Wallace. Plain Twp., Stark Co. Don M. Brown.

1655. *Gonolobus laevis* Mx. Sandvine. Crawford Co. Don M. Brown.

1657. *Vincetoxicum obliquum* (Jacq.) Britt. Large-flowered Vincetoxicum. Moonville, Vinton Co. Walter P. Porter.

1681. *Solanum dulcamara* L. Bitter-sweet. Burton, Geauga Co. C. A. Dambach.

1682. *Verbascum blattaria* L. Moth Mullen. Burton, Geauga Co. C. A. Dambach.

1686. *Penstemon digitalis* (Sweet) Nutt. Foxglove Beard-tongue. Canton, Stark Co. Don M. Brown.

1694. *Scrophularia marylandica* L. Maryland Figwort. Berne Twp., Fairfield Co. William Goslin.

1699. *Leucospora multifida* (Mx.) Penn. Leucospora. Hocking Twp., Fairfield Co. Robert Goslin.

1701. *Gratiola neglecta* Torr. Clammy Hedge-hyssop. Vinton Co. Len Stephenson. Athens Co. Walter P. Porter.

1701.1. *Gratiola viscidula shortii* Penn. Athens, Athens Co. Warren Abbott.

1707. *Aureolaria flava* (L.) Farw. Smooth False Foxglove. Rush Twp., Tuscarawas Co. C. W. Wallace.

1711. *Agalinis purpurea* (L.) Penn. Large-flowered Agalinis. Washington Twp., Henry Co. Liberty Twp., Wood Co. R. E. Shanks.

1720. *Veronica officinalis* L. Common Speedwell. Burton, Geauga Co. C. A. Dambach.

1726. *Veronica serpyllifolia* L. Thyme-leaf Speedwell. Pleasant Twp., Fairfield Co. William Goslin.

1728. *Veronica arvensis* L. Field Speedwell. Liberty Twp., Wood Co. R. E. Shanks.

1751. *Thalesia uniflora* (L.) Britt. Naked Broom-rape. Adams Co. John N. Wolfe.

1753. *Conopholis americana* (L. f.) Wallr. Squaw-root. Athens, Athens Co. Warren Abbott.

1754. *Leptamnium virginianum* (L.) Raf. Beech-drops. Richfield Twp., Henry Co. R. E. Shanks.

1759. *Stomoisia cornuta* (Mx.) Raf. Horned Bladderwort. Plain Twp., Stark Co. Don M. Brown.

1768. *Cynoglossum officinale* L. Hound's-tongue. Champaign Co. Margaret B. Church.

1769. *Cynoglossum virginianum* L. Wild Comfrey. Athens, Athens Co. Warren Abbott.

1773. *Lithospermum arvense* L. Corn Gromwell. Athens, Athens Co. Warren Abbott.

1786. *Echium vulgare* L. Blue-weed. Suffield Twp., Portage Co. Don M. Brown.

1787. *Verbena urticaefolia* L. White Vervain. Henry Twp., Wood Co. R. E. Shanks.
1789. *Verbena angustifolia* Mx. Narrowleaf Vervain. Bloom and Liberty Twps., Wood Co. R. E. Shanks.
1793. *Lippia lanceolata* Mx. Frog-fruit. Damascus Twp., Henry Co. R. E. Shanks.
1799. *Teucrium occidentale* Gr. Hairy Germander. Berne Twp., Fairfield Co. William Goslin.
1801. *Scutellaria lateriflora* L. Mad-dog Skullcap. Plain Twp., Wood Co. R. E. Shanks. Berne Twp., Fairfield Co. Robert and William Goslin.
1809. *Scutellaria galericulata* L. Marsh Skullcap. Oak Openings, Lucas Co. Floyd Bartley and Leslie L. Pontius.
1810. *Scutellaria nervosa* Pursh. Veined Skullcap. Wayne Twp., Tuscarawas Co. Don M. Brown.
1821. *Lycopus americanus* Muhl. Cutleaf Water-hoarhound. Berne Twp., Fairfield Co. Robert Goslin.
1823. *Lycopus virginicus* L. Virginia Water-hoarhound. Brown Twp., Carroll Co. Don M. Brown.
1826. *Collinsonia canadensis* L. Stone-root. Berne Twp., Fairfield Co. William Goslin. Damascus Twp., Henry Co. R. E. Shanks.
1827. *Koellia virginiana* (L.) MacM. Virginia Mountain-mint. Berne Twp., Fairfield Co. William Goslin. Washington Twp., Henry Co. R. E. Shanks.
1828. *Koellia flexuosa* (Walt.) MacM. Narrowleaf Mountain-mint. Berne Twp., Fairfield Co. William Goslin. Jackson Twp., Stark Co. Don M. Brown.
1830. *Koellia incana* (L.) Ktz. Hoary Mountain-mint. Dover Twp., Tuscarawas Co. Don M. Brown.
1839. *Melissa officinalis* L. Lemon Balm. Canton, Stark Co. Don M. Brown.
1840. *Hedeoma pulegioides* (L.) Pers. American Pennyroyal. Berne Twp., Fairfield Co. Robert Goslin.
1842. *Agastache nepetoides* (L.) Ktz. Catnip Giant-hyssop. Berne Twp., Fairfield Co. Robert Goslin.
1851. *Stachys palustris* L. Marsh Hedge-nettle. Liberty Twp., Wood Co. R. E. Shanks.
1867. *Monarda fistulosa* L. Wild Bergamot. Berne Twp., Fairfield Co. William Goslin.
1873. *Salvia lanceifolia* Poir. Lanceleaf Sage. North Union, Ross Co. Floyd Bartley and Leslie L. Pontius.
1880. *Plantago aristata* Mx. Large-bracted Plantain. Mill Twp., Tuscarawas Co. Irma Nelson.
1885. *Plantago virginica* L. Dwarf Plantain. Mill Twp., Tuscarawas Co. Irma Nelson.
1886. *Aralia spinosa* L. Angelica-tree. New Lexington, Perry Co. Walter Matz.
1887. *Aralia racemosa* L. American Spikenard. Plain Twp., Stark Co. Don M. Brown.
1889. *Aralia nudicaulis* L. Wild Sarsaparilla. Dover Twp., Tuscarawas Co. Irma Nelson.
1890. *Panax quinquefolium* L. Common Ginseng. Lawrence Twp., Tuscarawas Co. Don M. Brown.
1891. *Panax trifolium* L. Dwarf Ginseng. Plain Twp., Stark Co., and Lawrence Twp., Tuscarawas Co. Don M. Brown.
1896. *Sanicula marylandica* L. Black Snakeroot. Plain Twp., Stark Co. Don M. Brown. Damascus Twp., Henry Co., and Henry Twp., Wood Co. R. E. Shanks.
1901. *Torilis anthriscus* (L.) Gmel. Erect Hedge Parsley. New Vienna, Clinton Co. Katie M. Roads.
1902. *Deringa canadensis* (L.) Ktz. Homewort. Liberty Twp., Wood Co. R. E. Shanks. Berne Twp., Fairfield Co. William Goslin.
1903. *Chaerophyllum procumbens* (L.) Crantz. Spreading Chervil. Berne Twp., Fairfield Co. William Goslin.
1905. *Washingtonia longistylis* (Torr.) Britt. Long-styled Sweet-cicely. Wood Co. R. E. Shanks.

1914. *Heracleum lanatum* Mx. Cow-parsnip. Nimishellen Twp., Stark Co. Don M. Brown.
1916. *Angelica villosa* (Walt.) B. S. P. Hairy Angelica. Canton Twp., Stark Co. Dover Twp., Tuscarawas Co. Don M. Brown.
1918. *Oxypolis rigidus* (L.) Raf. Cowbane. Berne Twp., Fairfield Co. Robert and William Goslin.
1919. *Zizia aurea* (L.) Koch. Early Meadow-parsnip. Liberty Twp., Wood Co. R. E. Shanks. Highland Co. Katie M. Roads.
1920. *Zizia cordata* (Walt.) DC. Heartleaf Meadow Parsnip. New Market Twp., Highland Co. Katie M. Roads.
1921. *Taenidia integerrima* (L.) Drude. Yellow Pimpernel. Liberty Twp., Wood Co. R. E. Shanks.
1925. *Conium maculatum* L. Poison-hemlock. Chillicothe, Ross Co. Edward S. Thomas. Bellefontaine, Logan Co. A. G. Welshimer.
1926. *Sium cicutaefolium* Schrank. Water-parsnip. Berne Twp., Fairfield Co. Robert and William Goslin.
1927. *Aegopodium podograria* L. Goutweed. Bellefontaine, Logan Co. A. G. Welshimer.
1929. *Cicuta maculata* L. Spotted Water-hemlock. Liberty Twp., Wood Co. R. E. Shanks.
1934. *Erigenia bulbosa* (Mx.) Nutt. Harbinger-of-spring. Berne Twp., Fairfield Co. Robert Goslin.
1937. *Cornus asperifolia* Mx. Roughleaf Dogwood. Liberty Twp., Wood Co. R. E. Shanks.
1939. *Cornus femina* Mill. Panicled Dogwood. Liberty Twp., Wood Co. R. E. Shanks.
1943. *Nyssa sylvatica* Marsh. Tupelo. Harrison Twp., Henry Co. R. E. Shanks.
1952. *Mitchella repens* L. Partridge-berry. Dundee, Tuscarawas Co. Don M. Brown. Montgomery Twp., Wood Co. R. E. Shanks. Burton, Geauga Co. C. A. Dambach.
1954. *Diodia teres* Walt. Rough Buttonweed. Rose Twp., Carroll Co. Don M. Brown.
1956. *Galium boreale* L. Northern Bedstraw. Nimishellen Twp., Stark Co. Don M. Brown.
1958. *Galium circaezans* Mx. Wild Licorice. Harrison Twp., Henry Co., Liberty Twp., Wood Co. R. E. Shanks.
1959. *Galium lanceolatum* Torr. Lanceleaf Wild Licorice. Plain Twp., Stark Co. Don M. Brown.
1961. *Galium triflorum* Mx. Fragrant Bedstraw. Washington Twp., Henry Co. and Henry Twp., Wood Co. R. E. Shanks.
1962. *Galium mollugo* L. White Bedstraw. Prattsville, Vinton Co. Walter P. Porter.
1966. *Galium claytoni* Mx. Clayton's Bedstraw. Rowland's Pond, Athens Co. Walter P. Porter and P. S. Wamsley.
1967. *Galium trifidum* L. Small Bedstraw. Henry Twp., Wood Co. R. E. Shanks.
1972. *Viburnum acerifolium* L. Maple-leaf Arrow-wood. Harrison Twp., Henry Co. R. E. Shanks.
1980. *Vibernum cassinoides* L. Withe-rod. Canton Twp., Stark Co. Don M. Brown.
1981. *Viburnum lentago* L. Sheepberry. Henry Twp., Wood Co. R. E. Shanks.
1982. *Viburnum prunifolium* L. Black Haw. Monroe Twp., Henry Co. R. E. Shanks.
1986. *Triosteum perfoliatum* L. Common Horse-gentian. Dover Twp., Tuscarawas Co. Irma Nelson.
1997. *Lonicera glaucescens* Rydb. Glaucescent Honeysuckle. Henry Twp., Wood Co. R. E. Shanks.
2009. *Campanula americana* L. Tall Bellflower. Henry Twp., Wood Co. R. E. Shanks.
2014. *Specularia perfoliata* (L.) A. DC. Venus'-looking-glass. Liberty Twp., Wood Co. R. E. Shanks.
2015. *Lobelia cardinalis* L. Cardinal Lobelia. Washington Twp., Henry Co. R. E. Shanks.

2016. *Lobelia syphilitica* L. Blue Lobelia. Washington Twp., Henry Co. R. E. Shanks.
2019. *Lobelia inflata* L. Indian-tobacco. Bloom Twp., Wood Co. R. E. Shanks.
2021. *Lobelia spicata* Lam. Pale Spiked Lobelia. Plain Twp., Henry Co. R. E. Shanks.
2033. *Rudbeckia hirta* L. Black-eyed Susan. Berne Twp., Fairfield Co. William Goslin.
2043. *Helianthus microcephalis* T. & G. Small Wood Sunflower. Plain Twp., Stark Co., and Lawrence Twp., Tuscarawas Co. Don M. Brown.
2045. *Helianthus giganteus* L. Giant Sunflower. Washington Twp., Henry Co., and Plain Twp., Wood Co. R. E. Shanks. Jackson Twp., Stark Co. Don M. Brown.
2046. *Helianthus altissimus* L. Tall Sunflower. Sandy Twp., Stark Co. Don M. Brown.
2055. *Helianthus decapetalus* L. Thinleaf Sunflower. Union Twp., Logan Co. A. G. Welshimer.
2057. *Helianthus strumosus* L. Paleleaf Wood Sunflower. Plain Twp., Stark Co. Don M. Brown.
2076. *Bidens aristosa* (Mx.) Britt. Western Tickseed. Berne Twp., Fairfield Co. William Goslin.
2083. *Coreopsis tripteris* L. Tall Tickseed. Washington Twp., Henry Co. R. E. Shanks. Henley, Scioto Co. Katie M. Roads.
2087. *Polymnia uvedalia* L. Yellow Leaf-cup. Moonville, Vinton Co. Walter P. Porter and P. S. Wamsley.
2096. *Helenium autumnale* L. Common Sneezeweed. Damascus Twp., Henry Co. R. E. Shanks.
2097. *Helenium nudiflorum* Nutt. Purple-headed Sneezeweed. Goshen Twp., Tuscarawas Co. Irma Nelson.
2119. *Solidago squarrosa* Muhl. Stout Goldenrod. Waterloo Twp., Athens Co. Walter P. Porter and P. S. Wamsley.
2120. *Solidago bicolor* L. White Goldenrod. Canton, Stark Co. Don M. Brown.
2122. *Solidago flexicaulis* L. Zig-zag Goldenrod. Pleasant Twp., Fairfield Co. Robert and William Goslin. Brown Twp., Carroll Co. Don M. Brown.
2123. *Solidago caesia* L. Wreath Goldenrod. Richfield Twp., Henry Co. R. E. Shanks.
2129. *Solidago nemoralis* Ait. Gray Goldenrod. Washington Twp., Henry Co. R. E. Shanks.
2130. *Solidago canadensis* L. Canada Goldenrod. Berne Twp., Fairfield Co. Robert Goslin.
2131. *Solidago serotina* Ait. Late Goldenrod. Sandy Twp., Stark Co. Don M. Brown.
2134. *Solidago ulmifolia* Muhl. Elmleaf Goldenrod. Lawrence Twp., Tuscarawas Co. Don M. Brown.
2136. *Solidago neglecta* T. & G. Swamp Goldenrod. Harmon Twp., Clark Co. Helen Rea and E. S. Thomas.
2137. *Solidago juncea* Ait. Plume Goldenrod. Jackson Twp., Stark Co. Don M. Brown.
2141. *Euthamia graminifolia* (L.) Nutt. Bushy Fragrant Goldenrod. Berne Twp., Fairfield Co. Robert Goslin.
2145. *Sericocarpus asteroides* (L.) B. S. P. Toothed White-top Aster. Moonville, Vinton Co. Walter P. Porter and P. S. Wamsley.
2149.1. *Aster roscidus* Burgess. Dewy-leaf Aster. Oak Openings, Lucas Co. Floyd Bartley and Leslie L. Pontius.
2152. *Aster cordifolius* L. Common Blue Wood Aster. Plain Twp., Stark Co. Don M. Brown.
2153. *Aster lowrieanus* Port. Lowrie's Aster. Pike Twp., Stark Co. Don M. Brown.
2157. *Aster undulatus* L. Wavy-leaf Aster. Plain Twp., Stark Co. Don M. Brown.
2158. *Aster puniceus* L. Purple-stem Aster. Jackson Twp., Stark Co. Don M. Brown.
2160. *Aster novae-angliae* L. New England Aster. Berne Twp., Fairfield Co. Robert Goslin.

2163. *Aster prenanthoides* Muhl. Crooked-stem Aster. Berne Twp., Fairfield Co. Robert Goslin. Canton Twp., Stark Co. Don M. Brown.

2167. *Aster lateriflorus* (L.) Britt. Starved Aster. Plain Twp., Stark Co. Don M. Brown.

2168. *Aster hirsuticaulis* Lindl. Rough-stem Aster. Sandy Twp., Stark Co. Don M. Brown.

2170. *Aster multiflorus* Ait. Dense-flowered Aster. Canton Twp., Stark Co. Don M. Brown. Berne Twp., Fairfield Co. Robert Goslin.

2172. *Aster salicifolius* Lam. Willow Aster. Canton Twp., Stark Co. Don M. Brown.

2173. *Aster paniculatus* Lam. Panicled Aster. Rose Twp., Carroll Co. Don M. Brown.

2174. *Aster tradescanti* L. Tradescant's Aster. Sandy Twp., Stark Co. Don M. Brown. Greenfield Twp., Fairfield Co. Robert Goslin.

2178. *Erigeron pulchellus* Mx. Showy Fleabane. Jackson Twp., Stark Co. Don M. Brown.

2191. *Eupatorium sessilifolium* L. Upland Boneset. Canton Twp., Stark Co., and Lawrence Twp., Tuscarawas Co. Don M. Brown.

2210. *Anthemis arvensis* L. Field Dog-fennel. Jackson Twp., Stark Co. Don M. Brown.

2232. *Senecio obovatus* Muhl. Roundleaf Squaw-weed. Berne Twp., Fairfield Co. William Goslin.

2237. *Mesadenia atriplicifolia* (L.) Raf. Pale Indian-plantain. Washington Twp., Henry Co., and Plain Twp., Wood Co. R. E. Shanks.

2239. *Erechtites hieracifolia* (L.) Raf. Fireweed. Berne Twp., Fairfield Co. Robert and William Goslin.

2251. *Cirsium muticum* Mx. Swamp Thistle. Berne Twp., Fairfield Co. Robert Goslin. Washington Twp., Henry Co. R. E. Shanks.

2252. *Cirsium arvense* (L.) Scop. Canada Thistle. Athens Twp., Athens Co. Harold H. Moore.

2254. *Onopordon acanthium* L. Scotch Thistle. Edge of railroad tracks at Evergreen, Gallia Co. Clyde H. Jones.

2255. *Centaurea jacea* L. Brown Star-thistle. New Vienna, Clinton Co. Katie M. Roads.

2258. *Centaurea vochinensis* Bernh. Tyrol Star-thistle. Athens, Athens Co. R. Rypma.

2259. *Centaurea maculosa* Lam. Spotted Star-thistle. Ashland Co. H. M. Spandau. Plain Twp., Stark Co. Don M. Brown.

2266. *Cynthia virginica* (L.) D. Don. Virginia Cynthia. Moreland, Wayne Co. Don M. Brown. Berne Twp., Fairfield Co. William Goslin.

2273. *Tragopogon pratensis* L. Yellow Goat's-beard. Hocking Twp., Fairfield Co. Robert Goslin.

2274. *Tragopogon porrifolius* L. Salsify. Canton Twp., Stark Co. Don M. Brown.

2276. *Hieracium paniculatum* L. Panicled Hawkweed. Plain Twp., Stark Co. Don M. Brown.

2281. *Hieracium aurantiacum* L. Orange Hawkweed. Newark, Licking Co. Warren Abbott. Plain Twp., Stark Co. Don M. Brown.

2282. *Hieracium pratense* Tausch. Field Hawkweed. Jackson Twp., Stark Co. Don M. Brown.

2284. *Hieracium venosum* L. Veined Hawkweed. Athens, Athens Co. Warren Abbott. Burton, Geauga Co. C. A. Dambach.

2292. *Nabalus altissimus* (L.) Hook. Tall Rattlesnake-root. Plain Twp., Wood Co. R. E. Shanks.

2299. *Sonchus asper* (L.) Hill. Spiny Sow-thistle. Berne Twp., Fairfield Co. Robert Goslin.

2302. *Lactuca spicata* (Lam.) Hitchc. Tall Blue Lettuce. Berne Twp., Fairfield Co. Robert Goslin.

BOOK NOTICES

Simplified Statistics for the Agronomist

A full description of statistical procedures for the analysis of field experiments, without recourse to algebra, but with ample arithemtical examples, all in 33 pages, is the remarkable achievement of this little pamphlet. It commences with a practical discussion of experimental error and soil heterogeneity and leads through the t-test to the analysis of variance. It describes in full the lay-out and analysis of randomized block, Latin square, factorial, split-plot, and quasi-factorial experiments. The simultaneous analysis of two or more variables or covariance methods are not included. Explanations of the statistical operations do not involve the mathematical theory nor do they treat generally of the problem of biological variation; they appeal rather to the agronomist's logic in terms of practical considerations known to the field worker. Hence, for the experimenter who wants only a working knowledge of the analysis of variance as applied to field trials, this publication would seem ideal.—C. W. Cotterman.

Field Trials: Their Lay-out and Statistical Analysis, by John Wishart. 36 pp. Imp. Bur. Plant Breeding and Genetics, Cambridge, Eng. 1940. Price 216.

Animal Biology

Increase in knowledge may entail a change in concepts. Explanations which previously have been satisfactory, must often be revised in the light of new information. Textbooks especially must be kept as nearly abreast to information as possible. The textbook of zoology written by the late Professor Wolcott has recently been revised by his colleagues at the University of Nebraska. The organization of the first edition has been retained but many statements have been modified and new materials included. The work is well illustrated, sixty-four new illustrations have been added, approximately half of which are contained in the sections on reptiles and birds. A number of the illustrations used in the first edition have been improved. Except for the chapter on *Energy Changes in Organisms*, in which the concepts of oxidation within the organism are not handled in the light of modern physiological knowledge, the work is well done. This book designed as a text for a year's course in General Zoology, accompanied by laboratory, should be examined by those who wish to survey the animal kingdom.—*Paul E. Schaefer*.

Animal Biology, by Robert H. Wolcott. Second Edition, 649 pp., New York. The McGraw-Hill Book Company. 1940. $3.50.

A Century of Progress in Cellular Biology

Three interrelated topics of special interest to the cytologist and geneticist comprise the first volume of *Biological Symposia*, which were read at the 1938 meetings of the A. A. A. S. and are here presented in book form. The three symposia are titled: I. The Cell Theory, Its Past, Present and Future; II. Mating Types and Their Interactions in the Ciliate Infusoria; and III. Chromosome Structure. The volume itself is attractively printed. It contains contributions by 16 American biologists and will serve, on the biologist's bookshelf, to commemorate the centenary of the cell theory, even though, as shown by two symposium papers, the celebration must be regarded as somewhat overdue.

Though related, the three symposia differ greatly in the character of the papers which they contain. An interested outsider, desirous of studying the personality of the biologist, would find this book an excellent portrayal in three characteristic moods. The symposium on Cell Theory shows the biologist as a philosopher, somewhat exasperated by the immensity of his problem, carefully evaluating his past achievements, and using the full ponderosity of his language while describing his present difficulties. Following an introduction by Mayer and an historical review of microscopy by Woodruff are two very similar chapters by Karling and Conklin. These authors unite in taking from Schleiden and Schwann most of the credit commonly accorded them as founders of the cell theory. The next three papers by

Baitsell, Schrader, and Weiss deal in turn with cells as structural units, mitotic machines, and as individuals in development. Prof. McClung concludes with a discussion of the future. Collectively, these last four essays tell a great deal about what is not known at present about life.

Quite a different sort of biologist is revealed in the second symposium, wherein a surge of new discoveries on mating reactions in the ciliate Infusoria are reported by five enthusiastic protozoologists. This section is "refreshing reading," to quote Dr. A. F. Blakeslee, who inscribes the Foreward to the book. "One feels as if one were in the laboratory with the workers, seeing the results coming thick and fast and trying to figure out how they fit into a broad picture, what their relation may be to sex, to self-sterility and incompatibilities in higher forms." This symposium deals with discoveries dating from 1937. A wide array of new facts are reported which might be summarized by saying that much of the former confusion about the problems of conjugation and exdomixis in the Protozoa has been largely removed by the discovery of hereditary mating "types" and "groups" comparable to multiple sexes and mutually intersterile subspecies in higher organisms. Also of interest are the facts that different species vary greatly in their mating systems, that, in certain cases, Mendelian segregation and mutation are exhibited, and that, like hereditary traits in general, the mating reactions are also influenced by a variety of environmental factors. This symposium would seem to hold a great deal of interest to many different kinds of biologists because of the many parallelisms.

The last symposium on Chromosome Structure is the shortest of the three and reflects a steadier, perhaps more normal, state of growth in biological theory. In the first paper "On Coiling in Chromosomes," Dr. Nebel gives a good explanation of current theories and adds one of his own which is quite ingenious and well illustrated by photographs of models but which seems to require quite a few new assumptions to meet the shortcomings of alternative theories. A very informative paper by Waddington deals with recent discoveries in the chemistry and physics of chromosomes. Dr. Painter, rediscoverer of the giant salivary chromosomes of Diptera, reaffirms their multiple-chromonema nature by ontogenetic studies, and Dr. Demerec closes the symposium with a review of chromosome structure in the light of gene physiology.—*C. W. Cotterman.*

Biological Symposia, Volume I, edited by Jaques Cattell. 238 pp. Lancaster, Pa., The Jaques Cattell Press. 1940.

The cut opposite was inadvertently left out of the article "Notes on Some Ohio Aphids" by Clyde F. Smith in the May number of the Ohio Journal of Science.

APHIS ACRITUS
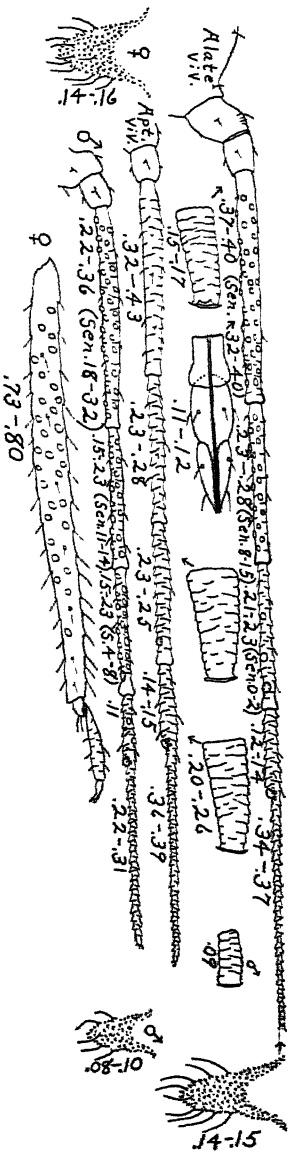
CAPITOPHOPUS OHIOENSIS
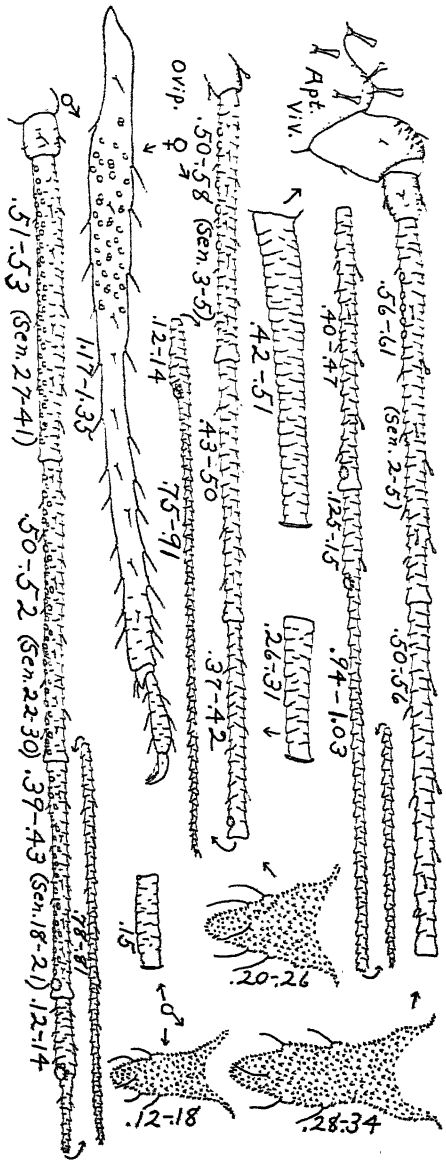
A RECORD OF THE BODY WEIGHT AND CERTAIN ORGAN AND GLAND WEIGHTS OF 3690 ANIMALS

GEORGE CRILE, M. D.,

Cleveland Clinic Foundation,

and

DANIEL P. QUIRING, Ph. D.,

Cleveland Clinic Foundation and Western Reserve University,
Cleveland, Ohio

The weight data presented in the following table are offered in the hope that they may be of value to the biologist, physiologist and particularly to the student of growth phenomena. They were collected in Northern Ohio and by several Cleveland Clinic Foundation Expeditions to various parts of the world. These expeditions included one to the South-western area of the United States, one to Brunswick Island, Georgia, one to Africa, one to Key West, Florida, one to the Northeastern arctic territory of Canada and one to Mexico and Guatemala. In addition, certain data are included which have been collected by W. W. Swett and associates of the Bureau of Animal Industry, Department of Agriculture, Washington, D. C., by S. Naccarati, and by Dr. Herbert Clark, Director of the Gorgas Memorial Laboratory, Panama. Certain data on primates were secured through the courtesy of the Department of Physiology of the Yale University Medical School. The material on the horses was made available to us through the co-operation of Dr. W. W. Dimock, head of the Animal Pathology Division of the University of Kentucky, who permitted us to make a large series of dissections in the laboratory of his division. The figures on the gorilla are based on a partial dissection of a specimen at the American Museum of Natural History, through the courtesy of Dr. W. K. Gregory and Dr. H. C. Raven. The data on the human being were obtained through the co-operation of Dr. Harry C. R. Darling, Sidney, Australia; Dr. Nils P. Larsen,

Honolulu, Hawaii; Dr. C. C. Sweet, Ossining, New York; Dr. Carlos Duran, Guatemala; and Dr. John Hertz, Copenhagen, Denmark; and on our own dissections.

With few exceptions, marked with an asterisk, our own data represent fresh weights taken immediately after the animal was sacrificed. The larger animals were weighed on a Chatillon scale of 600 pound capacity, in the case of the heaviest animals this necessitated quartering or cutting the body into sections to fit the scale. The smaller animals were weighed either in a Chatillon autopsy scale, a Cenoco triple beam balance or an Ohaus beam balance. The glands and organs likewise were weighed in these scales except for the very small glands which were weighed in an analytical balance.

It will be noted that some records are more complete than others; this is due in part to changes which were made in our program over the period of some ten years and in part to the impossibility of getting complete records for many of the animals. No attempt has been made to arrange the groups in order of relative development. A rough alphabetical listing has been made.

In connection with the degree of accuracy of the weights, in some instances these have been carried beyond the limits of error. Generally, however, we have attempted to hold to an accuracy of one per cent. In the case of animals which were weighed in pieces, we allowed five per cent for loss of blood and body fluids. All weights represent the body weight plus whatever mass was present in the stomach and intestine.

Under the heading "Remarks," we have given chiefly the locale or country from which the animal was obtained. In certain cases, other pertinent information has been included.

The scientific names have been checked by us and have been examined by Arthur B. Fuller, of the Cleveland Museum of Natural History. If any errors have occurred in naming, the authors take responsibility for them.

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Swett, W. W., Miller, Fred W., Graves, R. R., Black, W. H., and Creech, G. T. Comparative conformation, anatomy and udder characteristics of cows of certain beef and dairy breeds. J. of Agricultural Res., 55: 239–287, 1937.

Naccarati, Sante. On the relation between the weight of the internal secretory glands and the body weights and the brain weight. Anatomical Record, 24: 255–260, 1922.

INVERTEBRATES

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
.....	10	.....	ANNELIDS Earthworms......... *Lumbricus terrestris*	.00609	.0214	(Ganglia	and	ventral	nerve	cord)					Cleveland, O.
.....	5	.....	INSECTS Cockroach......... *Periplaneta americana*	.000092	.000105	(Ganglia	and	ventral	nerve	cord)					Cleveland, O.
.....	54	.....	Grasshopper......... *Melanoplus femur rubrum*	.000458	.00233	(Ganglia	and	ventral	nerve	cord)					Cleveland, O.
.....	35	M&F	Woodroach......... *Blaberus cranifer*	.004727	.0097	(Ganglia	and	ventral	nerve	cord)					Winter Park, Fla.
.....	5	.....	MOLLUSCS Slug......... *Limax maximus*	.00417	.0133	(Ganglia)									Cleveland, O.

VERTEBRATES
AMPHIBIA

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
650	1	M	Bullfrog......... *Rana catesbiena*	.339	......	.033	.06	1.37	6.42	2.23	1.73	1.81	......	......	North Carolina
1179 1180 1181 1182 1183 1184	6	M	" "	.5199	.4625	.0336	.1342	1.65	14.77	2.57	1.421	2.76	.373	24.56	Louisiana
1139 1140	2	M	Toad, Horned......... *Phrynosoma coronatum*	.025	.1383	.0044	.0093	.1204	.5705	.3927	.6397	.5705	.0311	......	Arizona
1137 1138 1141	3	F	" "	.0249	.1269	.0070	.0087	.1001	.8857	.2761	.2257	.6174	.0105	......	Arizona

BIRDS

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
702	1	M	Blackbird, Quiscalus quiscula aeneus	.082	2.92	.0116	.0133	1.159	2.63	1.917	1.299	1.743	.051	6.38	Little Mountain, O.
261	1	F	Bluebird, Sialia sialis sialis	.034	1.281	.006	.022	.383							Little Mountain, O.
262	1	M	"	.029	1.392	.0093	.013	.493							Little Mountain, O.
108	1	F	Bustard, Greater, Choriotis kori struthiunculus (Neumann)	5.540	12.94	.44	.33	60.25	98.61	40.25	22.09	70.48		490	Althai Plain, Africa
169	1	M	Bustard, Lesser, Haluaoetus bociler bociler (Daubin)	10.00	15.63	.91	.87	97	200	52.45	66.42	100		655	Althai Plain, Africa
136	1	F	"	1.100	7.62	.213	.237	11.93	17.63	10.18	6.07	14.35		120	Maji Moto Camp, Africa
15A	1	M	Buzzard, Steppe, Buteo vulpinus vulpinus (Gloger)	.558	7.9	.18	.26	4.58	10.87		3.36	4.64			Maji Moto Camp, Africa
24F	1	M	Buzzard, Turkey, Cathartes aura septemtrionalis	.494	9.3	.115	.156	10.24	20.99	7.95	10.11	14.73		170	Key West, Fla.
266	1	F	Catbird, Dumetella carolinensis	.033	1.412	.004	.004	.327				.607			Little Mountain, O.
706	1	M	Canary, Serinus canarius	.0171	.848	.0193	.0059	.2854	1.010	.336	.2673	.2516	.0184	2.296	Cleveland, O.
1258	1	F	"	.0153	.564	.009	.007	.133	.738	.230				1.74	Cleveland, O.
265	1	F	Cowbird, Molothrus ater ater	.066	2.693	.014	.017	1.06							Cleveland, O.
55A	1	F	Crane, Crested, Balearica pavonina	4.071	13.54	.34	.38	41.21	125	12	30.34	46.21			Lake Manyara, Africa
56A	1	M	"	4.825	12.85	.265	.30	32.37	86.1	11.2	21.62	42.05			Lake Manyara, Africa

No.	n	Sex	Species												Locality
60	1	M	Crane, Grey; *Grus canadensis*	1.651	8.58	.14	.248	19.01	29.34	10.97	11.71	15.33	.67	78.59	Key West, Fla.
241	1	M	Crow; *Corvus brachyrhynchos*	.337	9.3	.038	.077	3.2		1.94	1.88	9.97		6.60	Little Mountain, O.
50F	1	F	Dovekie; *Alle alle*	.102	1.93	.008	.015	1.24	2.51		1.88	1.41			Key West, Fla.
51F	1	M	"; "	.104	1.92	.009	.037	1.24	4.34	2.00	2.31	1.91		6.74	Key West, Fla.
646	1	M	Duck; *Nyroca affinis* (Eyton)	1.041		.133	.152	13.4	58.3	2.9	18.1	17.6			Willoughby, O.
29	1	F	Duck, Pintail; *Dafila acuta tzitzihoa*	.670	4.9548	.0559	.0818	8.34	30.33	1.70	8.14	17.13	.89	99.43	Churchill, Canada
154	1	F	Eagle, Fish; *Haliaetus vocifer vocifer*	3.500	12.93	.28	.40	32.23	46.28	22.28	18.43	47.33		150	Africa, Maji Moto Camp
5, 22	2	F	Eagle, Tawny; *Aquilla rapax rapax* (Temminick)	2.625	14.09	.19	.45	18.54	43.45	32.84	14.16				Maji Moto Camp, Africa
88	1	M	"; "	1.67	13.62	.12	.35	9.24	42.73	30.2	3.82	27		150	Maji Moto Camp, Africa
11, 12	2	M	"; "	2.438	13.91	.31	.50	14.17	37.55	30.9	13.57	23.18			Maji Moto Camp, Africa
114A	1	F	Egrette, Great White; *Casmerodius albus melanorhynchos* (Wagler)	1.03	6.12	.13	.21	9.25	33.02		8.16	33.10			Africa, Maji Moto Camp
113A	1	M	Egrette, Yellow-Bill; *Mesophyox intermedia brachyrhyncha* (Brehm)	.525	4.7	.07	.14	5.0	16.53	5.16	3.72	5.35			Africa, Maji Moto Camp
109, 110, 111	3	F	Flamingo; *Phoeniconaias minor* (Geoffroy)	1.483	6.99	.27	.34	14.68	40.27	2.97	17.02	21.35			Africa, Maji Moto Camp
16, 17	2	M	"; "	1.598	8.05	.57	.59	13.53	40.91	3.82	19.0	23.32			Africa, Maji Moto Camp
718, 719, 720, 721	4	F	Fowl, Leghorn; *Gallus bankiva*	1.263	3.916	.2153	.186				10.05	10.48	2.20	90.99	Cleveland, O.
	7	F	"; "	.0437	.9971	.0038	.0095		1.8524						6 days old
	13	M	"; "	.0464	1.0556	.0036	.0147		1.6242						6 days old
	6	F	"; "	.0682	1.2107	.0063	.0163		3.4482						13 days old
	14	M	"; "	.0801	1.3378	.0083	.0185		3.1548						13 days old

BIRDS—Continued

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
....	15	F	Fowl, Leghorn	.1197	1.5001	.0094	.0198	....	4.2529	....	....	....	....	....	20 days old
....	15	M	"	.1197	1.5411	.0089	.0263	....	4.2091	....	....	....	....	....	20 days old
....	12	F	"	.1719	1.7148	.0132	.0228	....	5.1676	....	....	....	....	....	27 days old
....	8	M	"	.1601	1.7039	.0113	.0254	....	5.0124	....	....	....	....	....	27 days old
....	10	F	"	.2231	1.9261	.0167	.0305	....	6.1386	....	....	....	....	....	35 days old
....	10	M	"	.2273	1.9173	.0143	.0368	....	6.6918	....	....	....	....	....	35 days old
....	12	F	"	.2951	2.1168	.0233	.0390	....	8.4172	....	....	....	....	....	48 days old
....	8	M	"	.3168	2.1142	.0198	.0441	....	9.0164	....	....	....	....	....	48 days old
....	6	F	"	.3978	2.3487	.0300	.0498	....	11.843	....	....	....	....	....	62 days old
....	11	M	"	.3918	2.3334	.0294	.0611	....	13.719	....	....	....	....	....	62 days old
....	10	F	"	.3596	2.3811	.0089	.0864	....	11.032	....	....	....	....	....	87 days old
....	10	M	"	.3532	2.4980	.0536	.1135	....	12.365	....	....	....	....	....	87 days old
....	10	F	"	.4907	2.5822	.1097	.0989	2.80	12.761	3.34	3.83	3.88	.78	....	108 days old
....	10	M	"	.5007	2.8056	.0631	.1265	3.18	15.305	3.75	4.34	4.39	.68	....	108 days old
....	16	F	"	.6151	2.7224	.0762	.0973	3.91	14.498	3.58	4.17	3.78	.95	....	136 days old
....	8	M	"	.7331	2.9279	.0894	.0714	4.19	16.188	4.25	4.54	4.41	.97	....	136 days old
602	1	M	Fowl, White Orpington *Gallus bankiva*	2.200	3.55	.140	.260	8.78	45.9	6.39	12.9	13.17	....	....	Cleveland, O.
18A	1	F	Goose, Egyptian *Alopochen aegyptiaca*	1.935	7.64	.34	.42	18.51	34.31	....	9.75	35.2	....	....	Lake Manyara, Africa
186A	1	M	Guinea Fowl *Numida meleagris*	1.620	4.20	.293	.36	14.22	28.6	....	7.34	29.08	....	....	Maji Moto Camp, Africa
25	1	M	Gull, Bonepartes *Larus philadelphia*	.205	2.49	.0216	.0529	3.44	9.12	3.14	3.20	7.12	....	21.56	Churchill, Canada
44F 10F}	2	F	Gull, Herring *Larus argentatus*	.535	5.08	.040	.133	5.24	27.33	7.74	....	....	....	....	Key West, Fla.
53F	1	F	Gull, Ring-Billed *Larus delawarensis*	.720	8.72	.051	.12	7.35	23.51	8.74	7.45	9.13	....	154	Key West, Fla.
21F	1	F	Gull, Shearwater *Puffinus griseus*	.268	3.01	.031	.049	2.46	10.08	3.27	3.23	2.45	....	18.21	Key West, Fla.

No.	n	Name	Sex													Locality
145 146	2	Hawk, Red-Tailed — *Buteo borealis*	F	1.029	10.025	.107	.0656	114	2035	14.10	21.22	1.216	6.87	9.27	.....	Little Mountain, O.
681	1	"	F	.....	.....	.....	.....	.....	6.94	.....	.....	.....	.....	7.7	18.38	Juvenile, Willoughby, O.
229	1	Hawk, Sharp-shinned — *Accipiter velox velox* (Wilson)	F	.520	5.70	.042	.....	.110	3.70	.....	.....	.....	.....	.....	.....	Little Mountain, O.
58F	1	Hawk, Sparrow — *Falco sparverius* (Linnaeus)	M	.112	2.51	.016	.028	1.12	2.52	3.30	1.11	1.52	.....	.....	7.43	Key West, Fla.
163	1	Hornbill, Ground — *Bucorvus cafer*	M	2.150	26.25	.23	.25	56.61	57.58	35.45	23.30	52.27	.....	.....	260	Maji Moto Camp, Africa
712	1	Hummingbird — *Amazilia tzacatl tzacatl* (De la Llave)	F	.0048	.1998	.00045	.00035	.1138	.2511	.1201	.0391	.0951	.....	.....	.....	Samayac, Guatemala
55B	1	Loon, Red-Throated — *Gavia stellata*	F	1.530	6.12	1.33	.223	22.72	60.87	5.47	22.71	22.62	.....	.....	97.42	Tavane, Canada
55A 55C 52F	2	"	M	1.563	6.38	.210	.219	22.24	74.02	4.89	27.61	22.31	.....	.....	.....	Tavane, Canada
26	1	Man-O'-War — *Fregata aquila*	M	1.405	9.45	.089	.175	16.59	35.88	12.99	.....	.....	.....	.....	.....	Key West, Fla.
90A	1	Merganser, Red-Breasted — *Mergus serrator*	M	.770	5.289	.0657	.1033	11.01	19.77	2.76	9.67	18.16	.22	.....	46.30	Tavane, Canada
	1	Ostrich, Masai — *Struthio camelus massaicus* (Neumann)	M	123.	42.11	17.33	23.01	1205	2050	.....	920	2900	.....	.....	23133	Maji Moto Camp, Africa
143	1	"	M	.....	.....	5.5	.....	.....	.....	.....	256	.....	10.7	.....	.....	Zoo Specimen, Cleveland, O.
225	1	Owl, Horned — *Bubo virginianus virginianus*	M	1.177	13.70	.085	.165	8.60	.....	.....	.....	.....	.....	.....	.....	Little Mountain, O.
6A	1	Partridge — *Francolinus sephaena*	M	.208	1.50	.02	.043	1.46	8.65	.....	2.70	.....	.....	.....	.....	Maji Moto Camp, Africa
7F 23F	2	Pelican — *Pelicanus occidentalis*	F	3.290	17.45	.183	.993	22.12	73.15	12.73	.....	29.83	.....	.....	255	Key West, Fla.
1257	1	Pheasant — *Phasianus colchicus*	M	.625	3.289	.051	.12	2.84	9.175	5.32	4.82	5.61	.....	.....	56.5	Little Mountain, O.
263	1	Phoebe — *Sayornis phoebe*	M	.0181	.793	.006	.005	.207	.207	.....	.....	.....	.....	.....	.....	Little Mountain, O.

BIRDS—*Continued*

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
264	1	F	Phoebe	.0175	.750	.0025	.0055	.165	....	....	....	....	....	....	Little Mountain, O.
271	1	F	Pigeon *Columba livia*	.247	2.285	.031	.046	4.651	....	....	....	....	....	....	Little Mountain, O.
268, 269, 270	3	M	" *Columba livia*	.282	2.694	.028	.0421	4.836	....	....	....	....	....	....	Little Mountain, O.
24A, 24C, 24D	3	M	Ptarmigan, Willow *Lagopus lagopus*	.542	2.377	.0255	.0273	7.863	12.99	2.316	3.87	9.61	....	....	Churchill, Canada
24B	1	F	" *Lagopus lagopus* "	.540	2.800	.017	.036	9.46	13.405	3.022	4.870	10.74	....	....	Churchill, Canada
108	1		Raven *Corvus corax*			.031					2.428				Catalina Mountains, Arizona
259, 260	2	M	Robin *Turdus migratorius migratorius*	.0693	2.09	.0105	.0213	1.018	1.677	....	....	....	....	....	Little Mountain, O.
28	1	F	Scaup, Greater *Nyroca marila*	.787	4.7859	.0855	.1850	8.00	23.00	1.76	9.11	18.01	....	99.15	Churchill, Canada
.....	11	F	Sparrow *Passer domesticus*	.02326	1.0185	.0041	.0069	.3926	1.0873	.5179	.357	.3996	.0428	2.681	Cleveland, O.
....	75	M	Sparrow, Song *Melospiza melodia melodia*	.02357	1.0278	.0042	.0063	.4077	1.2062	.4591	.345	.3674	.0426	2.698	Cleveland, O.
255	1	F	"	.021	1.10	.0145	.005	.235	....	....	....	....	....	....	Cleveland, O.
14A	1	M	Stork, Abdim. *Sphenorhynchus abdimi* (Lichenstein)	.950	7.3	.23	.46	8.40	27.94	8.88	8.80	10.36	....	....	Maji Moto Camp, Africa
84A	1	M	Stork, European. *Ciconia ciconia ciconia* (Linnaeus)	3.350	16.24	.43	.49	28.75	71.4	9.15	26.24	27.2	....	....	Maji Moto Camp, Africa
82A, 83A	2	F	"	3.334	15.78	.40	.44	32.12	61.06	16.5	19.84	33.64	....	....	Maji Moto Camp, Africa

No.	Ct.	Sex	Species												Locality
195A	1	M	Stork, Hammerhead... *Scopus umbretta*	.3175	3.93	.037	.061	7.22				8.16			Maji Moto Camp, Africa
107A) 108A)	2	M	Stork, Marabou... *Leptophilos crumeniferous* (Lesson)	7.130	30.14	.64	2.06	55.24	110	27.89	42.94	72.23		692	Maji Moto Camp, Africa
257	1	M	Swallow, Barn... *Hirundo erthrogaster*	.0215	.904	.006	.007	.302							Little Mountain, O.
256) 258)	2	F	" "	.021	.879	.0083	.0085								Little Mountain, O.
27	1	F	Teal, Green-winged... *Nettion carolinensis*	.305	3.116	.0281	.0430	2.88	8.17	1.16	3.105	9.218	42.0	33.84	Churchill, Canada
....	10	F	Starlings " *Sturnus vulgaris* "	.05835	1.8248	.0063	.0113	.8688	2.1952	1.056	1.080	1.089	.04115	5.6575	Cleveland, O.
....	15	M	Vulture " " *Pseudogyps africanus*	.05736	1.8701	.0063	.0147	.9293	1.9874	.8384	.9829	1.0736	.0665	5.2473	Cleveland, O.
9A	1	F		5.270	19.60	.40	.46	37.85	70.20	16.24	35.80				Maji Moto Camp, Africa

CARNIVORES

No.	Ct.	Sex	Species												Locality
132	1	M	Bear, American... *Euarctus americanus*			25.0	6.0				176.5				Zoo specimen, Detroit, Mich.
600	1	F	Bear, Grizzly... *Ursus horribilis*	142.88	233.9	53.6	65.5	1132.5			547.8		304		Zoo specimen, Cleveland, O.
624	1	M	Bear, Polar... *Thalarctos maritimus*	199.57	489	17.3	10.8	1161	4639	10.1	1292	1701	245	8164	Zoo specimen, Cleveland, O.
567	1	F	" "	317	507	21.5	29.8	1220	4126		730	2580			Zoo specimen, Cleveland, O.
103	1	F	Cat, Civet... *Spilogale arizonae arizonae*		6.0	.028	.086				3.78				Catalina Mountains, Arizona
99	1	M	" "			.007	.072				4.34				Catalina Mountains, Arizona
....	1	....	Cat, Domestic... *Felis domesticus*	.576	16.0		.5	3.0	31.		7.5	7.5	2.5		Juvenile, Panama
766) 48F)	2	M&F	" "	1.542	18.0		1.	10.	86	16.5	16.5	15.	6.5	355	Adult, Panama
	2	F	" "	2.885	23.46	.21	.639	12.38	92.67	10.06	22.07	32.6	6.48		Key West, Fla.

CARNIVORES—*Continued*

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
232 1253 1254 632 749	5	M	Cat, Domestic........	3.778	28.37	.408	.571	16.82	126.8	9.67	44.5	42.7	11.7	33.4	Cleveland, O.
36F		M	" (feralized)	5.012	28.23	.460	.795	19.61	184.2	11.86	49.94	28.47	11.02	......	Key West, Fla.
10A 67A	2	M	Cat, Genet........ *Genetta tigrina suahelica* (Matschie)	1.302	15.89	.29	.49	7.51	49.68	3.72	8.93	12.99	......	......	Maji Moto Camp, Africa
153A	1	F	"	1.525	15.35	.04	.19	8.46	58.54	344	14.05	22.55	......	97	Maji Moto Camp, Africa
104 113	2	M	Cat, Ringtailed........ *Bassariscus astutus*		17.1	.083	.353	......	......	......	11.6	......	......	......	Arizona
152A	1	F	Cat, Wildcat........ *Felis ocreata*	2.700	28.48	.10	.19	5.86	32.75	6.41	10.07	9.0	......	78	Maji Moto Camp, Africa
148	1	M	Cheetah........ *Acinonyx jubatus*	22.20	2.449	1.09	......	......	......	82.5	......	......	......	......	Zoo specimen, Cleveland, O.
1292	1	M	"	40.82	......	13.05	2.91	159	1000	49	145	360	47.2	......	Zoo specimen, Cleveland, O.
......	1	......	Coati mundi........ *Nasua narica panamaensis* (Allen) "	.399	23.3	......	.4	2.0	17.5	......	4.0	5.3	1.8	......	Adult, Panama
714	1	M	Coyote........ *Canis latrans*	6.25	44.17	1.54	.54	37.97	150	2.33			5.50	......	Guatemala
667	1	F	"	8.510	84.24	.6901	1.049	72.71	292.5	11.11	80.07	61.28	14.21	......	Cedar Vale, Kansas
89	1	F	"		80.0	1.8	.560	......	......	......	80.69	......	......	......	Kaibab Forest, Arizona
213A 214A 216A	3	M	Dog........ *Canis familiaris*	14.56	79.99	1.14	1.74	127	760	10.97	84.8	362	......	1553	Maji Moto Camp, Africa—African mongrel

No.	n	Sex	Species												Locality
180A) 212A)	2	F	Dog	12.47	81.14	1.35	1.45	120	665	13.11	88	288		1430	Maji Moto Camp, Africa
672)	1	M	Greyhound	24.49	105.9	2.34	3.36	308.8	1067	12.36	158	363.5			Memphis, Tenn.
35) 57)	2	M	Huskies	31.75	130.7	2.85	3.16	297	1438	10.88	248	431	175	1944	Churchill, Canada
276	1	M	"	26.94	79.3	11.3	10.6				216.2				Zoo—originally from Alaska
8F) 228F)	2	F	Mongrel	14.75	66.53	1.11	1.09	95.4	300	9.73	44.65	108.1		712	Key West, Fla.
362) 204)	2	M	"	11.26	87.6	3.36	1.54	126.3	465.2	16.85		138.4			Cleveland, O.
120) 369) 870) 367)	4	F	Dog, Collie-Police	23.71	84.63	2.93	2.07	182.6	693		152	192.7			Cleveland, O.
	1	:	" "	19.28	90	8.6	7.0								
615	1	M	Dog, Police	38.42	95.2	23.8	6.1	261							Adult, Panama / Cleveland (goiter)
134	1	F	Fox, Bat-eared / *Otocyon megalotis*	3.335	26.09	.49	.49	24.65	125	4.65	31.91	35.05		660	Maji Moto Camp, Africa
90) 91)	2	F	Fox, Grey / *Urocyon cinereo argenteus scotti*		32	.066	.222				17.17				White Tank Mts., Arizona
69F	1	M	" "	3.749	37.28	.154	.390	21.97	50.80	4.02	17.43	19.12		425	Miami, Fla.
92) 95) 100) 115)	4	M	" "		35.2	.266	.329				24.09				White Tank Mts., Arizona
188	1	F	Fox, Red / *Vulpes fulva* (Desmarest)			.405	.420				24.95				Little Mountain, O.
647)	1	F	Fox, White / *Vulpes lagopus innuitus* (Merriam)	4.625	53.30	.1469	.5285	41.75		4.18					Churchill, Canada
648)	1	M		3.385	44.50	.763	.353			5.8					Churchill, Canada
188A) 28A)	2		Hyena, Spotted / *Crocuta crocula*	62.37	175	6.68	15.08	447	3194	40.42	400	6809		6804	Maji Moto Camp, Africa
95A) 140)	2	M	Jackal / *Thos mesomelas*	2.85	46.	.78	.508	21.33	122.5	6.8	23.03	30.08		308	Lake Manyara and Katetti, Africa
678	1	F	Jaguar / *Felis onca*	34.47	147	1.72	7.46	186	894	17.28	164.5	576	62.12		Zoo specimen, jungle bred, S. Amer.

CARNIVORES—Continued

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
709	1	F	Kinkajou.... *Potos flavus aztecus*	2.62	31.05	.56	.19	14.3	98.6	1.9	......	78.5	......	......	Guatemala City, Guatemala
608	1	M	Leopard.... *Felis pardus*	48	135	48.55	6.93	200	900	31.4	......	500	104.3	......	Hyperplastic thyroid, zoo, Detroit, Mich.
561	1	F	Leopard, Infant....	8.618	121	1.3	2.3	52	278	......	86	183	......	......	Zoo, Cleveland, O.
144 } 267	2	F	Lion, Cubs....	56.09	167	87.08	7.81	345	1182	......	325	......	......	......	Zoo, Cleveland, O.
1144 } 131	1	F	*Felis leo* " "	20.41	163	4.415	9.20	144.6	723.8	31.3	193.7	334.2	46.4	......	Zoo, Cleveland, O.
185 } 219	2	F	" "	87.34	......	16.33	8.62	391.1	......	......	......	......	......	......	Zoo, California
579 } 689	3	M	"	124	229.2	636.9	15.51	1163	......	51.8	......	2600	157.7	......	Zoo specimen, Philadelphia and Cleveland, O.
37A } 38A	2	M	"	190.8	258	20.57	32.73	1018	5725	59.23	1610	2300	825	......	Maji Moto Camp, Africa
612	1	M	Lion, Mountain.... *Felis oregonensis*	28.79	106.7	2.20	9.6	184	1255	9.2	131.7	326	......	......	New Mexico
106	1	F	"	......	......	1.6	4.1	......	......	......	140	......	......	......	Catalina Mountains, Arizona
98	1	M	Lynx.... *Lynx baileyi*	......	......	.35	.60	......	......	......	24.6	......	......	......	Florence, Arizona
159A	1	M	Mongoose.... *Ichneumia albicauda*	4.40	28.30	.21	.61	28.84	61	4.0	34.96	58	......	......	Maji Moto Camp, Africa
571	1	M	Puma.... *Felis bangsi costaricensis* (Merriam)	25.96	129	1.40	10.2	......	......	......	......	......	......	......	Juvenile, Panama
......	......	......	Raccoon.... *Procyon lotor pumilis* (Miller)	5.175	40.	1.33	3.22	......	......	......	......	......	......	275	Adult, Panama

No.	n	Sex	Species													Locality
64	1	F	"	2.226	33.55	.190	1.55	19.73	140	3.32	35.85	19.41		225		Key West, Fla.
562	1	F	"	4.536	40.5	.195	1.4	31.2	136		37	38	13.8			Zoo specimen, Cleveland, O.
563	1	M	"	5.216	42.7	.261	.9	42.5	187		35.7	187	13.6			Goiter—Zoo, Cleveland, O.
168F	1	F	"			.222	1.651									Cumberland Island, Georgia
321	1	M	Skunk. / *Mephitis mephitis*	1.700	10.3	.274	.468	9.82	45.7		10.1					New York State
110, 127	2	F	"	2.260	10	.096	.348									Cleveland
102	2	M	Skunk, Hog-nosed. / *Conepatus mesoleucus*		15.5	.068	.279				7.51					Catalina Mountains, Arizona
111, 117	1	F	"		16.0	.054	.211				7.51					Arizona
189	1	M	Serval. / *Felis capensis*	9.955	66.74	.42	1.03	37.3	225	18.02	100	125		400		Maji Moto Camp, Africa
87, 151	2	F	"	5.819	53.16	.33	.40	28.45	86.18	10.23	40.34	50.72		350		Maji Moto Camp, Africa
288	1	F	Tiger. / *Felis tigris*	160.	225	68.2	16	432	1818			1020	915			Zoo specimen, Cleveland
261	1	M	"	209.	302	50.5	20.8	698				1888				Jungle bred captive
53A, 53B, 53C	3	M	Weasel, Arctic. / *Mustela arctica*	.1693	5.64	.108	.015	2.83	9.67	.153	1.80	3.85	.713			Tavane, Canada
782	1	F	Wolf, Russian. / *Canis lupus lupus*	.121	3.47	.015	.030	1.95	5.5	.110	1.81	3.60				Cleveland, O.
627	1	M	"	22.68	119	13.	2.4	246	626	18.20	187	807				Zoo specimen, Cleveland, O.
672	1	M	Wolf, Timber. / *Canis lubilus*	29.94	152	3.49	3.37	315	925	16.84	223	379	44.3			Ely, Minnesota

PINNEPEDIA

No.	n	Sex	Species													Locality
40	1	F	Seal, Bearded. / *Erignathus barbatus*	109.7		6.13	6.95	515								Juvenile, Chesterfield Inlet, Canada
39	1	F	"	281.	460	22.83	22.04	1245	5454	63.06	1320	4536		26330		Chesterfield Inlet, Canada
618	1	M	Seal. / *Phoca richardi geronimensis*	107.3	442	10.02	6.27	1435	4485	60.72	894	1880	520			California

PINNEPEDIA—Continued

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
149	1	M	Seal..........	.....	378	5.2	6.0	.....	.....	.....	418	.....	.....	.....	Zoo specimen, Cleveland, O.
18, 31, 37	3	M	Seal, Ringed.... *Phoca hispida*	39.46	251	3.49	2.49	281	1244	73.34	249	738	101	2992	Churchill (2), Chesterfield Inlet (1), Canada
36, 41	2	F	"	39.68	255	3.44	3.41	302	930	70.20	236	730	150	.....	Chesterfield Inlet, Canada
45	1	M	Walrus....... *Odobenus rosmarus* (Linnaeus)	79.38	.....	.....	.....	.....	3625	.....	.....	.....	520	.....	3 months old, Churchill, Canada
38	1	F	"	55.79	737	13.68	7.20	650	2300	13.2	725	1625	200.	2425	3 months old, Keewatin, Chesterfield Inlet
43	1	M	"	667	1126	70.04	27.07	4536	19504	26.63	4536	9072	.....	29484	Tavane, Canada
46, 47, 48	3	M	"	595.6	.....	66.67	20.15	.....	.....	.....	.....	.....	.....	.....	Walrus Islands, off Tavane, Canada

CETACEA

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
70	1	M	Porpoise........ *Phocaena phocaena*	142.43	1735	18.29	10.41	738	2962	57.19	.....	5250	53.02	13255	Key West, Fla.
748	1		Whale, Blue....... *Balaenoptera musculus*	58059	6800	3450	1385	.....	.....	.....	.....	.....	.....	.....	Queen Charlotte Islands, Canada
1, 32	2	F	Whale, White....... *Delphinapterus leucas*	303.23	2354	65.94	29.23	1722	4825	22.01	1857	7936	153	9296	Churchill, Canada
7, 19, 33, 34	4	M	" "	441.31	2349	111.04	29.20	2454	6807	31.71	2214	12093	200	12075	Churchill, Canada

CHIROPTERA

No.	Sex	Species											Locality
5	M&F	Bat, Vampire. *Desmodus rotundus murinus* (Wagner)	.028	.936	.028	.012							Adult, Panama

EDENTATES

No.	Sex	Species											Locality
1	…	Ant Bear. *Cyclops didactylus dorsalis* (Gray)	.086	4.11	.15	.72							Panama
1	…	Anteater. *Tamandua tetradactyla chiriquensis* (Allen)				.25	1.0	4.0		2.0	1.0	.5	Infant, Panama
1	M&F	Armadillo.	1.409	23		1.0	2.0	23.		12.5	16	1.5	Juvenile, Panama
2	M	"	3.692	25		.75	18.0	76.5		21.0	27.0	7.0	Adult, Panama
1	M	*Dasypus novemcinctus fenestratus* (Peters)	2.086	9.5	.195	.83							Adult, Panama
7	M&F	"	.471	6.0		.56	2.3	22.3		5.6	5.64	1.6	Infant, Panama
4	M&F	"	1.392	8.2		1.1	6.0	40.2		11.0	10.5	4.0	Juvenile, Panama
1	F	"	1.818	8.5	.16	.71							Juvenile, Panama
1	M	"	3.701	14.2	.42	.80	14.7		.38				
10	M&F	"	3.401	7.5		1.2	9.0	106		16.3	24.0	7.4	Adult, Panama
1	…	Sloth, Three-toed. *Bradypus griseus griseus* (Gray)	.676	15.		1.0	3.0	20		9.0	7.0	2.0	Infant, Panama
1	F	"	1.115	14	.07	.20							Juvenile, Panama
1	M	"	1.601	13.0	.19	.30							Juvenile, Panama
4	M&F	"	2.005			1.1	6.1	42		12.5	27.4	6.4	Juvenile, Panama
10	M&F	"	2.894	15.	.66	1.16							Adult, Panama
1	F	"	3.121	15.1		.94	7.5	64.1		16.4	20.9	8.0	Adult, Panama
7	M&F	Sloth, Two-toed. *Choloepus hoffmanni* (Peters)	3.774	18.0	.7	1.15							Adult, Panama
		"	4.825	23.07	3.307	.6857							Adult, Panama
1	F	"	5.271	26.0	.30	1.03							Adult, Panama

ELASMOBRANCH FISHES

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
47F	1	M	Ray, Electric. — *Torpedo torpedo*	.345	.78	.029		.22	6.9	1.3	12.9				Key West, Fla.
1F	2	M	Ray, Sting — *Desyatis sabina*	17.58	54.49	1.76		47.58	815	30.67	107.2			410	Key West, Fla.
73F	1		Shark, Sand — *Carcharias littoralis*	2.675	6.03	.084		6.83							Key West, Fla.
9F	1	F	" — "	35.38	48.8	1.81		41.6	2875	44.24	96.4		98.82	1375	Miami, Fla.
63F	1		"												
4F	1	M	Shark, Tiger — *Galeocerdo tigrinus*	35.83	50.03	2.57		40.14	2925	52.21			150	750	Key West, Fla.
72F	1	F-P	"	123	82.55	4.05		115		40.8					Miami, Fla.
74F	1	F	"	200	107.5	12.73		291.5	40370	88.43					Miami, Fla.

BONY FISHES

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
65F	1	F	Barracuda — *Sphyraena barracuda*	4.794	4.34	.064		37.78	38.93	25.25				260	Key West, Fla.
35F	1	M	" — "	5.078	3.83	.11		42.25	72.7	29.07				409	Key West, Fla.
59F	1	F	"	8.654	5.7	.060		51.6	80.31	45.21			13.37	430	Key West, Fla.
31F	1	M	"	9.130	6.3			60.31		38.39					Key West, Fla.
25F	1	M	Bonita — *Gymnosarda alleterata*	6.291	3.57	.051		29.43	128	33.8			20.4	351	Key West, Fla.
1151 1152 1154 1155	4	M	Carp — *Cyprinus carpio*	1.0421	1.2833	.0089		1.617		2.865	6.779		2.54	96.44	Cleveland, O.
1153 1156	2	F	Carp — "	1.061	1.191	.0080		1.554		3.142	4.88		2.32	70.10	Cleveland, O.
7A	1	M	Catfish — (Of genus *Clarias*)	2.894	1.84			6.1	17.65		16.75				Maji Moto Camp, Africa

No.	Number	Sex	Name											Locality
1	91A	M	Catfish (Of species *Crilli*)	10.78	8.2			52.2		3.67	76.41			Maji Moto Camp, Africa
2	1188 1189	M	Cisco — *Argyrosomus artedi*	.1621	.2995			.39	1.592	1.08	1.81	.155	10.78	Churchill, Canada
1	1193	F	Codfish — *Gadus callarias*	10.6	5.0401	.620		15.90	161.4	60.36	19.93	10.09	580.0	Boston, Mass.
8	1194 1197 1205	F	"	2.625	2.2180	.0257		4.09	97.1	26.91	9.4	2.01	159.7	Boston, Mass.
3	1195 1196 1198	M	"	2.518	1.9792	.0476		3.90	96.2	26.73	11.40	2.15	179.2	Boston, Mass.
1	2F		Eel, Green moray — *Gymnothorax funebris*	3.510	.51	.054	1.51	4.62	101.5	1.39		4.28	325	Key West, Fla.
1	619	M	Goldfish — *Carassius auratus*	.00554	.069	.009		.014						Cleveland, O.
1	618	F	Grouper, Black — *Mycteroperca bonaci xanthastica* (Jordan and Swaine)	.00952	.097	.004		.026		.140			.98	Cleveland, O.
1	49F	M	"	2.712	1.99	.032		2.08	11.66	13.19			55.47	Key West, Fla.
1	13F	M	Grunt, White — *Haemulon plumieri* (Lacepede)	.300	.81	.01		.31	3.55	4.47		.18	5.19	Key West, Fla.
6	1199 1200 1201 1202 1203 1204	F	Haddock — *Melanogrammus aeglefinus*	3.275	2.0502	.0692		5.71	132.6	26.16	11.08	2.64	291.5	North Atlantic Coast
1	11	M	Hogfish — *Lachnolaimus maximus*	.480	.91	.014		.452	3.70	4.97		.35	5.02	Key West, Fla.
1	43	M	Jack, Common — *Caranx hippos*	2.305	2.97	.031		4.87	18.7	33.25		2.66		Key West, Fla.
1	41	F	Jack, Yellow — *Caranx bartholomoei*	4.274	7.56	.043		11.62		9.52				Key West, Fla.
1	22	M	"	4.812	4.72	.058		13.96	65.13	20.22		8.7	182	Key West, Fla.
1	8	M	Jewfish — *Promicrops itaiara* (Lichtenstein)	32.89	2.31	.32		49.23	350	33.6	56.8	17	1200	Key West, Fla.

BONY FISHES—Continued

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
34	1	M	Kingfish........ *Scomberomorus regalis*	2.43	2.18	.037	....	5.33	....	....	....	....	....	....	Key West, Fla.
621	1	M	Mackerel........ *Scomberomorus maculatus*	.765	.640	....	....	....	....	....	....	....	....	....	North Atlantic Ocean
19) 649)	2	F	" "	1.457	1.61	.030	....	2.93	6.21	7.91	....	....	1.7	2.92	Key West, Fla.
20	1	F	Muttonfish........ *Lutianus analis*	2.49	2.09	.048	....	5.12	14.26	19.15	....	....	1.17	....	Key West, Fla.
61	1	F	Palometa........ *Trachinotus glaucus*	8.504	3.08	.110	....	24.83	86.25	79.13	....	....	7.42	302	Key West, Fla.
623	1	F	Perch........ *Perca flavescens*	.192	.337	.002	....	.44	2.96	1.4	....	....	....	7.92	Lake Erie, Cleveland
1163) 1164) 1165) 1166) 1167) 1168)	6	M	"	.167	.254	.0035	....	.3087	1.476	....	.459	....	.149	4.85	Lake Erie, Cleveland
617	1	....	Pike........ *Esox lucius*	.82	.597	....	....	....	....	3.9	....	....	....	....	Lake Erie, Cleveland
1157) 1158) 1160) 1162)	4	M	"	.3523	.464	.0047	....	.660	3.55	4.88	1.777	....	.421	21.67	Lake Erie, Cleveland
1159) 1161)	2	F	"	.3738	.535	.0118	....	.560	3.780	4.915	1.555	....	.420	20.8	Lake Erie, Cleveland
1207) 1208) 1209) 1211)	4	F	Salmon........ *Salmo salar*	5.361	1.143	.0170	....	10.72	96.56	8.014	39.59	....	11.71	230.9	Atlantic Ocean, off Maine Coast

No.	N	Sex	Species												Locality
1210 1212	2	M	" "	4.922	1.029	.010	……	15.22	69.46	7.84	36.20	……	11.00	216.8	Atlantic Ocean, off Maine Coast
695	1	M	" "	3.93	1.257	.035	……	6.42	……	……	……	……	……	……	Atlantic Ocean, off Maine Coast
694	1	F	" "	5.412	1.387	.137	……	7.92	79.7	8.9	……	……	……	……	Atlantic Ocean, off Maine Coast
620	1	……	Smelt. *Osmerus mordax*	.04766	1.09	.006	……	1.29	……	……	……	……	……	……	Lake Erie, Cleveland
14	1	M	Snapper, Vermilion. *Rhombophites auro-rubens* (Cuvier and Valenciennes)	.202	.65	.006	……	.33	1.76	2.54	……	……	……	3.11	Key West, Fla.
1178	1	M	Trout, Brown. *Salmo trutta*	.292	.570	.007	……	.385	3.885	2.29	1.25	……	1.205	20.10	Castalia, O.
1213 1214 1215 1216 1217 1218	5	F	Trout, Northern. *Cristivomer namaycush*	3.24	1.323	.0134	……	5.17	52.43	9.33	27.97	……	1.77	220.3	Manitoulin Island, Ont.
1218	1	M	" "	2.50	1.233	.0095	……	4.34	36.00	7.26	20.92	……	2.16	154.7	Manitoulin Island, Ont.
1170 1173 1174 1175	4	F	Trout, Rainbow. *Salmo irideus*	.2177	.415	.0044	……	.280	2.156	1.519	1.093	……	.585	19.35	Adult, Castalia, O.
1171 1175	2	M	" "	.2608	.454	.0074	……	.307	2.598	1.809	1.443	……	.54	25.	Adult, Castalia, O.
1172 1176	1	F	" "	.1101	.315	.0022	……	.155	1.415	1.13	.485	……	.265	8.00	Yearling, Castalia, O.
1177	1	M	" "	.0428	.178	.0026	……	.095	.610	.665	.123	……	.115	4.25	Infant, Castalia, O.
1185 1186	2		Trout, Salmon. *Salmono gairdneri*	2.75	.818	.0163	……	6.22	40.74	4.35	20.64	……	2.86	89.38	Churchill, Canada
622	1	M	Trout, Speckled. *Salvelinus fontinalis*	.85	83	……	……	……	……	1.9	……	……	……	25.5	Pennsylvania
697	1	F	" "	.255	.439	……	……	99	5.86	2.02	……	……	.22	16.01	Pennsylvania
696	1	M	" "	.2301	.466	……	……	1.15	3.75	1.94	3.32	……	.17	28.24	Pennsylvania
26	1	M	Tuna. *Thunus secundodorsalis*	5.21	3.09	.056	……	31.22	139	85.81	……	……	……	216	Key West, Fla.
15	1	M	Turbot. *Balistes carolinensis*	.295	.872	.005	……	.304	12.86	3.36	……	……	.09	5.4	Key West, Fla.

BONY FISHES—Continued

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
1145 1149 1150 }	8	M	Whitefish. *Coregonus clupeaformis*	.7465	.503	.0153	......	.892	8.84	2.34	7.98	......	.75	42.88	Lake Erie
1147 }	3	F	"	.7986	.593	.0091	......	.973	10.61	2.69	8.2	......	.60	38.67	Lake Erie
1148 12 }	1	F	Yellowtail (fish). *Ocyurus chrysurus* (Bloch)	.255	.94	.007	......	.37	2.41	4.2	......	......	......	7.78	Key West, Fla.

INSECTIVORES

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
631	1	M	Mole. *Scalopus aquaticus*	.0396	1.16	.0095	.0175	.272	1.548	......	.629	.737	......	......	Little Mountain, O.
......	39	F	*Shrew. *Blarina brevicauda*	.0163	.3443	.0021	.0087	.1723	.8896	.0011	.2041	.3575	......	......	Cleveland
......	29	M	"	.0188	.352	.0026	.0048	.1922	1.092	.0018	.240	.4214	......	......	Cleveland

MARSUPIALS

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
......	2	......	Opossum. *Didelphis marsupialis etensis* (Allen)	.215	4.5	.14	......	......	......	......	......	......	......	......	Infant, Panama
......	3	......	"	.224	3.3	......	.38	1.41	13.0	......	.57	2.3	......	......	Infant, Panama
......	8	M&F	"	.666	3.8	......	1.01	3.4	......	5.6	8.0	2.83	2.7	......	Juvenile, Panama
......	4	M&F	"	1.147	4.8	......	1.0	5.0	67.0	......	7.5	9.5	......	......	Adult, Panama
......	1	......	Opossum, Woolly. *Philander laniger pallidus* (Thomas)	.158	......	......	.25	1.5	7.0	......	2.0	2.0	1.0	......	Juvenile, Panama
......	1	......	"	.222	......	......	1.0	3.0	9.0	......	4.0	3.0	1.5	......	Adult, Panama

*Preserved weights.

PRIMATES

No.	No.	Sex	Name												Remarks
......	1	F	Baboon...... *Papio cynocephalus*	7.900	140	437	2.30	......	......	......	......	......	......	......	Juvenile, Department of Physiology, Yale Univ.
23A	1	M	" "	19.51	175	1.8	2.05	79.94	367	13.18	70.92	175	......	250	Moto Umbo Camp, Africa
98A	1	F	Monkey, Grey...... *Cercopithecus mitis kibonotensis* (Lonnberg)	1.22	50.3	.172	.22	6.56	29.65	......	7.84	9.98	......	......	Maji Moto Camp, Africa
92A	2	M	" "	2.9	61.46	.39	.41	7.59	50	9.94	8.71	14.39	......	350	Maji Moto Camp, Africa
4A	1	M	" "	4.55	66.6	.15	3.05	35.32	106	......	20.63	41.6	......	......	Maji Moto Camp, Africa
......	10	M&F	Howler, Black...... *Alouatta palliata inconsonans* (Goldman)	.673	42.88	......	.588	3.9	22.65	......	6.19	9.88	6.8	......	Infant, Panama
......	3	M&F	" "	2.683	48.1	......	.67	14.1	84.9	......	15.4	22.7	36.75	......	Juvenile, Panama
......	28	M&F	" "	6.174	50.34	.45	1.16	20.67	201	......	35.95	38.68	45.68	......	Adult, Panama
......	2	F	" "	4.309	54.25	.55	.8	......	......	......	......	......	......	......	Juvenile, Panama
......	2	F	" "	6.577	54.05	.55	.95	......	......	......	......	......	......	......	Adult, Panama
......	2	M	" "	7.938	53.45	.55	.95	......	......	......	......	......	......	......	Infant, Panama
......	2	......	Howler, Brown...... *Alouatta palliata palliata*	.429	37	.45	.45	1.9	13.3	......	3.2	6.5	1.7	......	Juvenile, Panama
......	5	M&F	" "	1.209	37.6	......	1.6	8.0	41.9	......	12.5	11.5	2.8	......	Adult, Panama
......	6	M&F	" "	3.119	42.3	.45	1.5	7.8	118	......	21.33	28.3	3.33	......	Adult, South America
224	1	F	Humboldt...... *Lagothrix humboldii*	5.26	86.2	......	1.2	48	......	......	......	63.5	......	......	Maji Moto Camp, Africa
156A	1	F	Lemur...... *Galago senegalensis*	.20	5.0	.015	.125	1.38	6.03	3.7	1.54	1.44	......	17.6	New York
221	1	F	Lemur, Ring-tailed...... *Lemur catta*	1.725	21.8	.27	.232	8.2	......	......	24.7	24.7	......	......	Juvenile, Laboratory specimen Yale Univ. and C. C. Lab.
405	1	F	Macaque, Rhesus...... *Macacus rhesus*	1.39	72.0	.179	.885	5.3	57.2	......	9.8	......	......	......	Yale Univ. and C. C. Lab.
......	7	F	" "	3.627	93.1	.578	.990	12.2	......	......	......	68.5	......	......	Yale Univ. and C. C. Lab.
......	4	M	" "	3.292	91.7	.611	.75	12.7	69	35	2.0	2.0	1.0	......	Infant, Panama
......	.	......	Monkey, Night...... *Aotus zonalis* (Goldman)	.212	......	......	1.0	1.5	8.0	......	2.0	2.0	1.0	......	

PRIMATES—Continued

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
	18	M&F	Monkey, Night	1.926	88.6	.785	1.06	7.65	74.5		11.6	17.3	8.6		Juvenile, Panama
	11	F	"	9.163	109	1.28	2.12								Adult, Panama
	6	M	"	8.89	118	1.42	2.23								Adult, Panama
	19	M&F	"	1.029	74.79		1.04	4.49	42.77		7.76	11.98	14.5		Juvenile, Panama
	11	M&F	Spider, Red. *Ateles geoffroyi* (Kuhl)	2.805	103		1.06	14.52	98.97		16.97	26.99	29.32		Juvenile, Panama
	63	M&F	"	7.63	107		1.75	32.5	213		31.2	51.38	40.8		Adult, Panama
	5	F	"	.860	64.0	.175	.585								Infant, Panama
	5	F	"	5.143	110.6	.798	1.65								Juvenile, Panama
	3	M	"	4.999	94.7	.64	2.0								Juvenile, Panama
	6	M	"	7.787	117	.90	2.05								Adult, Panama
	14	F	"	8.912	102.9	1.04	1.95								Adult, Panama
	2		"	.407	58.0		.75	2.75	19		4.5	6.5	2.0		Infant, Panama
	18	M&F	Spider, Black. *Ateles dariensis* (Goldman)	1.926	88.6	.785	1.06	7.65	74.5		11.6	17.3	8.6		Juvenile, Panama
	11	F	"	9.163	108.8	1.28	2.12								Adult, Panama
	6	M	"	8.89	118.4	1.42	2.23								Adult, Panama
	183	M&F	Squirrel (Marmoset). *Leontocebus geoffroyi* (Pucheran)	.191	9.67		.56	1.34	9.33		1.87	3.13	1.16		Infant, Panama
	4	F	"	.340	10.4	.10	.25								Juvenile, Panama
	3	M	"	.453	11.1	.133	.23								Juvenile, Panama
	19	M&F	"	.475	11.04		.53								Juvenile, Panama
	8	M&F	"	.793	19.9		.63	3.02	16.53		2.89	3.91	1.38		Adult, Panama
	8	M	"	.903	24.00	.11	.30	3.91	25.41		4.24	8.48	1.65		Adult, Panama
	2	M	Sykes. *Cercopithecus*	4.937	60.7	1.14	.878	29.97	119.6		10.70	21.36	85.16		Maji Moto Camp, Africa
	4	M	Vervet. *Cercopithecus aethiops centralis* (Neumann)	3.955	60.89	.279	.554	32.03	86.23	8.98	15.06	25.01			Maji Moto Camp, Africa

ID	No.	Sex	Name												Locality
93A	1	F	"	1.225	50.3	.172	.220	6.56	29.65		7.84	9.98		250	Juvenile, Maji Moto Camp, Africa
...	4	F	"	2.718	71.6	.4	1.43								Panama
			White-face *Cebus capucinus linnaeus*												
...	5	M	White-face	3.833	73.3	.38	1.23								Panama
...	6	F	"	1.252	60.8	.26	.70								Juvenile, Panama
...	7	M	"	1.725	75.5	.34	.61								Juvenile, Panama
...	14	M&F	"	3.101	72.18		1.06	18.6			14.3	34.07	11.3		Adult, Panama
...	6	M&F	"	1.317	66		.97	7.53			8.56	20.44	5.7		Juvenile, Panama
...	27	M&F	"	.500	53.28		.568	3.06			4.04	7.93	2.10		Infant, Panama
...	60	M&F	"	.607	19.9		.63	3.68	25.6		3.99	7.20	.9		Adult, Panama
			Yellow Titi *Saimiri orstedii orstedii reinhardt*												
...	3	M	Yellow Titi	.907	25.3	.15	.447								Panama
...	2	...	"	.167	19.4		.20	.85	7		1.3	2.5	.3		Infant, Panama
...	2	...	"	.24	22		.45	1.25	12		2.5	4.9	.65		Juvenile, Panama
...	3	F	"	.603	25	.16	.323		25.6						Adult, Panama

ANTHROPOIDS

ID	No.	Sex	Name												Locality
...	1	F	**Chimpanzee** *Troglodytes niger*				3.8								Yale Univ. Dept. of Physiology
...	1	F-P	"			8.0	8.9								Yale Univ. Dept. of Physiology
215	1	M	"	25.85	430.5	10.1	5.0	184.6							Emaciated specimen from New York
18A	1	M	"	56.69	440	4.85	8.93	250	1210		210	600		6200	Budonga Forest, Masindi, Uganda, Africa
19A	1	F	"	43.99	325	4.55	8.4	219							Budonga Forest, Masindi, Uganda, Africa
...	1	M	**Gorilla** *Gorilla gorilla*	181.		6 est.	.35 est.								American Museum of Nat. History, New York
1291	1	M	Chinese	57.2	1248	21.54	10.1								Age: 70 yrs. Australia

ANTHROPOIDS—Continued

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
1339	1	M	Chinese	…	1297	13.3	5.35	…	…	…	…	…	…	…	Age: ? Hawaii
1338	1	M	"	…	1268	11.4	9.9	430	…	…	…	…	…	…	Age: ? Hawaii
1340	1	M	Hawaiian	95	1235	16.7	…	220	1040	…	185	1315	60	…	Age: 36 to 40, Hawaii
755	1	M	Maya-Quiche Indian	42	1270	35	15	210	1270	…	170	755	80	…	Age: 25. Death from T. B.
757	1	M	"	43.4	1375	80	14	240	…	…	…	…	…	…	Age: 35. Death, Septicemia
758	1	M	"	49.9	1400	30	10	155	…	…	…	…	…	…	Age: 32. Death, Double pneumonia
1169	1	M	"	36.3	1280	11.1	5.6	226	…	…	…	…	…	…	Age: 45. Death, Cachexia
1334	1	M	- "	45.0	1190	108	10.0	159	…	…	…	…	…	…	Age: 32. Death, Pneumonia
1336	1	M	"	37.0	1100	10.0	5.0	225	…	…	…	…	…	…	Age: 17. Death, Cachexia
1335	1	F	"	45.8	1000	10.0	10.0	200	…	…	…	…	…	…	Age: 28. Death, Cachexia
1341	1	F	Filipino	…	1109	25.1	9.3	…	…	…	…	…	…	…	Age: 39. Hawaii
1337	1	M	"	…	1513	16.8	4.2	…	…	…	…	…	…	…	Age 53. Hawaii
751	1	M	Negro, Aborigine	76.2	1348	36.5	…	…	…	…	…	…	…	…	Age 66. Australia. Death, Pneumonia
1312	1	M	American	86.2	1265	19.8	16.7	365	1520	…	…	…	…	…	Age: 41. American
1255	1	M	"	71.2	1280	18.2	11.8	465	1500	…	…	…	…	…	Age: 24. American born Negro
753, 754, 4, 8	4	M	"	73.0	1365	31.77	12.69	389	…	…	259	…	…	…	Age: ? American

No.	n	Sex	Race										Age / descent
1316	1	M	White, American	78.5	1540	37.3	16.4	331	2010	292			Age: 25. Czech descent
1327	1	M	Dane boy	36.0	1327	14	11	220					Age:13yrs.Denmark
1333	1	F	Dane woman	61	1200	17	13	300					Age:47yrs.Denmark
1332	1	F	"	46	1160	23	14	260					Age:68yrs.Denmark
1330	1	F	"	43	1240	14	18	320					Age:65yrs.Denmark
1326	1	F	"	63	1180	17	14	450					Age:78yrs.Denmark
1324	1	F	"	43	1350	15	13	220					Age:50yrs.Denmark
1323	1	F	"	44	1300	10		310					Age:44yrs.Denmark
1322	1	F	"	45	1140	15		410					Age:60yrs.Denmark
1321	1	M	Dane male	51	1500	24		380					Age:55yrs.Denmark
1325	1	M	"	83	1420	29	19	520					Age:68yrs.Denmark
1328	1	M	"	56	1570	47	17	380					Age:28yrs.Denmark
1329	1	M	"	61	1490	26	15	410					Age:39yrs.Denmark
1381	1	M	"	51	1310	27		290					Age:55yrs.Denmark
1318	1	M	White, American	81.6	1350	42.0	12.0	370	1200	320			Age: 22 yrs. German descent
762	1	M	"	79.4	1450	42.63	9.42	330	1500	110	1280	100	Age: ? Irish descent
1311	1	M	"		1274	35	12.9	390	1970				Age 54 yrs. Polish descent
1813	1	M	"	81.6	1130	20.0	16.6	400	1730				Age 54 Yrs. Polish descent
3	1	M	Pole, Immigrant	74.0	1377	23.92	10.94	382					Age: ? Cleveland, O.
759	1	M	White, American	50	1480	48.47	14.96	325	1300	330			Age: ? Scotch descent, New York
1315	1	M	"	65.8	1310	23.6	17.6	340	1780	310			Age: 30 yrs. Swedish descent
1319	1	M	"	74.8	1410	40	13.8	330	2250				Age: 29 yrs.
1318	1	M	"	74.3	1360	47.7	9.4	264	2800				Age: 30 yrs. Ukranian descent
1342	1	F	"		1300	25.5		300			165		Age: ? Adult American
217	1	F	"	57	1351	22.9	12.0	340					Age: ? Adult American
228 / 227 / 610	8	M	"	68	1411	23.30	8.46	306					Age: ? Adult American, descent unknown

REPTILES

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
233	1	M	Alligator...... *Alligator mississip-piensis*	.105		.35	.40	1.39							Infant
1191, 1192	2	M	"	.351	1.61	.176	.076	1.62	6.99	1.73	1.52	2.97	211	13.83	Infants, Florida
134	1	F	"	52.4	7.23	3.50	4.00			15.96	161				Jacksonville, Fla.
628	1	F	"	80.0		4.28	6.62	137	708			393			Great Lakes Expo.
171	1	M	"	109 est.		3.11	12.85								Cumberland, Ga.
218	1	M	"	173		6.90	5.80	92.20	900	30.86		1770		2800	Musa Island, Fla.
71	1	M	"	205		8.83	5.40	255	522	25.54		1400	135	7000	Miami, Fla.
1251	1	M	"			13.32	11.96	318				628			Florida
183	1	F	"	90 est.		3.77	4.17								Cumberland, Ga.
186	1	M	Crocodile...... *Crocodylus americanus*	134	15.60	5.20	4.30	134	1145			1125			Musa Island, Fla.
670	1	F	Gila Monster...... *Heloderma suspectum*	.514	.729	.152	.050	4.17	35.00			6.45			Arizona
713	1	F	Iguana Iguana...... *Iguana iguana*	1.34		.117	.215	2.60	33.35			3.70		42.6	Guatemala
68	1	F	Iguana Lizard...... *Amblyrhynchus cristatus*	4.19	1.44	.040	.090	21.51	60.40	1.06	11.60	64.4		610	Florida
......	15	M&F	Lizard...... *Lacerta viridis*	.050	.121	.008	.020		2.50		.58		.080		Europe—data from Naccarati
59	1	F	"	.026	.134	.005	.004	.091	.628	.144	.21				Africa
679	1	F	Snake, Black...... *Coluber constrictor*	.590	.271	.131	.182	6.08							Little Mountain, O.
1190	1	M	"	.286	.303	.056	.056	.960	2.57	.219	2.58	3.45	.78	12.02	Laboratory specimen
616	1	F	Boa Imperator...... *Boa imperator*	.417	.299	.114	.103			.165		4.13			Little Mountain, O.
710	1	F	"	1.829	.440	.15	.15	5.64	30.37	.550	9.57	14.0			Guatemala

No.	n	Sex	Species	1	2	3	4	5	6	7	8	9	10	11	Locality
668	1	F	Snake, Garter... *Thamnophis sirtalis* "	.052	.077	.....	.....	.....	.....	.....	.....	.....	.....	.....	Willoughby, O.
680	1	F-P	Python... *Python molurus*	.057	.123	.020	.076	1.02	.....	.....	.....	.....	.....	.....	.....
178	1	M	"	6.140	1.123	1.33	2.68	18.50	1.12	.....	.....	.12	.....	300	Engurika, Africa
	20	M&F	Snake, Water... *Tropidonotus natrix*	.070	.1	.01	.035	2.80	.....	.88	22.62	5.57	.....	.....	Europe—data from Naccarati
66F	1	F	Water Moccasin... *Agkistrodon piscovorus*	.728	.64	.50	1.06	64.45	.61	13.47	.....	.....	.....	.....	Everglades, Fla.
	6	M&F	Snake, Green Water... *Zamenis viridis flavus*	.22	.209	.045	.08	4.82	.....	1.93	.....	.125	.....	.....	Europe; data from Naccarati
	30	M&F	Turtle... *Emys europea*	.250	.25	.025	.028	7.3	.....	1.38	.....	.16	.....	.....	Europe; data from Naccarati
	30	M&F	Turtle... *Testudo graeca*	.320	.30	.036	.031	8.5	.....	1.55	.....	.18	.....	.....	Europe; data from Naccarati
700	1	M	Turtle... *Clemmys guttatus*	2.163	1.36	.125	.413	7.05	53.5	1.35	8.45	31.95	2.25	108.5	Thompson, O.
66A	1	F	Turtle... *Chelydra serpentina*	5.125	.98	.48	.62	13.43	160	.72	24.50	85	.....	.....	Maji Moto Camp, Africa
62F	1	F	Turtle, Green... *Chelonia midas*	68.04	5.81	3.46	3.27	180	540	21.08	.....	.....	62.57	.....	Key West, Fla.
6F	1	M	Turtle... "	114.30	8.60	24.55	3.84	435	775	66.20	840	4.40	250	8750	Key West, Fla.
1252	1	M	*Clemmys guttatus*	.185	.....	.....	.57	.....	.....	.20	.....	.....	.....	.....	Cleveland, O.
325	1	F	Turtle, Leatherneck... *Amyda forex*	3.253	2.50	.51	.44	16.0	90.0	15	.....	.....	.....	.....	Florida
601	1	M	Turtle, Snapping... *Macrochelys lacertina*	1.848	1.01	.59	.51	12.88	184	1.21	15.9	34.90	16.41	.....	Sandusky, O.

RODENTS

No.	n	Sex	Species	1	2	3	4	5	6	7	8	9	10	11	Locality
	1		Agouti, Brown... *Dasyprocta punctata dariensis* (Goldman)	1.400	15.00	.....	.5	10	60	.....	14	10	5	.....	Infant, Panama
	3	M&F	Agouti, Spotted... "	2.059	12	.....	48	9.2	63.22	.....	10.7	12.89	5.23	.....	Juvenile, Panama
	2	M&F	"	3.172	18.34	.....	.98	17.54	85	.....	15.39	16.0	6.04	.....	Adult, Panama
	1	M	*Cuniculus paca virgatus* (Bangs)	.891	20.5	.101	.40	.....	.....	.....	.....	.....	.....	.....	Juvenile, Panama
	2	M&F	"	1.373	10	.....	1.4	5.5	65.0	.....	10.5	16.5	5.00	.....	Juvenile, Panama

RODENTS—*Continued*

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
.....	3	M&F	Agouti, Spotted	3.627	21.85		1.6	16.10	187		22.7	23.5	12.07		Adult, Panama
.....	1	M	"	4.559	48	.82	3.1	16.57	99.82		35.86	63.47			Adult, Panama
1286	1	M	"	4.18	25.48	.207	.228								Michigan
1290	1	F	Beaver / *Castor canadensis* "	5.83	29.52	.644	.752	27.0	203		72.60	33.3	4.75		Michigan
.....	2	M&F	Capybara / *Hydrochoerus isthmius* (Goldman)	27.670	52.21		5.2	84.13	577	1.50	69.75	227	50.58		Adult, Panama
.....	1		" "	7.089				24.18	113		28.06	38.50	16.3		Infant, Panama
.....	3	M&F	" "	14.96			2.72	55.06	509		81.0	88.99	75.3		Juvenile, Panama
33 49	2	F	Chipmunk / *Tamias striatus*		1.60	.003	.008								Arizona
703 671	2	M	*fisheri* (Howell)	.075	2.22	.030	.070	.597	5.55	.556	.756	.719	.222	4.65	Cleveland
34 35 38 51	4	M	" "		1.73	.002	.015				.535				Arizona
50 55 57 41 44	5	F	Gopher, Pocket / *Thomomys fulvus fulvus* (Woodhouse)		1.33	.0041	.012				1.15				Arizona
53 59	2	M	" "		1.20	.006	.014				.820				Arizona
174 175	2	F	Gopher, Pocket / *Geomys cumberlandius* (Bangs)			.013	.021								Arizona

No.	n	Sex	Species												Locality
170 173	2			.....	.....	.022	.005	.....	.....	.....	.....	.....	.....	.....	Arizona
775	1	F-P	Guinea Pig — *Cavia culleri*	.351	3.63	.022	.005	1.72	10.94	.88	2.79	5.86	.52		Young adult, Cleveland
1132 1135	2	M	"	.361	4.10	.053	.334	1.27	13.80	.93	3.43	4.62	.71		Young adult, Cleveland
773 1134	2	F	"	.324	3.80	.056	.316	1.31	31.93	.95	3.81	3.27	1.08		Young adult, Cleveland
	56	F	"	.21494	3.32	.036	.180	1.29	12.06	.....	2.829	2.934			Cleveland
	46	M	"	.21457	3.28	.035	.135	1.29	11.73	.....	2.821	2.563			Cleveland
	10	F	"	.432	4.00	.071	.348	1.67	16.7	1.04	3.72	4.63	.925		Cleveland
	10	M	"	.456	4.23	.096	.402	1.86	21.17	.84	4.16	5.12	.750		Cleveland
135	1	F	Hare, African — *Lepus capensis*	2.93	10.23	.190	.50	30.0	51.91	7.37	12.20	17.91		295	Maji Moto Camp, Africa
248 251	2	F	Hare, Arctic — *Lepus arcticus arcticus*	1.901	14.36	.160	.240	28.45	66.11	4.59	19.29	43.79			Tavane, Canada
249 250	2	M	"	2.640	13.90	.099	.191	28.87	65.22	4.75	25.44	44.04			Tavane, Canada
50A 50C 50D 50E	4	F	Lemming, Brown — *Lemmus trinucronatus* (Richardson)	.032	1.126	.0058	.0167	.434	2.33	.0230	44.04	.804			Churchill, Canada
50B	1	M	"	.048	1.312	.0046	.0251	.600	3.80	.0242	.525	.740			Churchill, Canada
3 4 10B 10E	4	M	Lemming, Rock — *Dicrostonyx rubricatus richardsoni*	.0521	.8983	.0042	.0138	.311	2.63	.1451	.774	.827	.210		Churchill, Canada
10A 10C 10D	3	F-P	"	.0552	.8447	.0089	.0177	.381	3.05	.062	.841	.884			Churchill, Canada
171	1	M	Mouse, African — *Mastomys coucha microdon*	.0218	.7132	.001	.0095	.122	.944	.075	.265	.2408		2.63	Maji Moto Camp, Africa
674 630B	8	F	*Mouse, Jumping — *Zapus hudsonicus*	.0193	.6961	.001	.008	.1557	1.124	.028	.218	.246	.0261		Little Mountain, O.
630C 630A	1	M	"	.0152	.522	.003	.005	.133	.743	.025	.266	.243			Little Mountain, O.
1A	1	F-P	Mouse, Dormouse — *Claviglis saturatus* (Dollman)	.0223	.705	.004	.002	.1132	.851	.063	.192	.205			Maji Moto Camp, Africa

RODENTS—Continued

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
145	1	M	Mouse, Dormouse	.0177	.551	.006	.0042	.116	.308	.052	.091	.272		.75	Maji Moto Camp, Africa
66, 68	2	M	Mouse, Grasshopper — Onychomys			.0011	.0237				.374				Seligman, Arizona
69	1	F	"	.0237	.6606	.0014	.040	.1612	1.082	.0239	.392	.4036			Arizona
	67	M	*Mouse, Meadow — Microtus drummondi	.0229	.6464	.0032	.0085	.1609	1.129	.0236	.3634	.3930			Churchill, Canada
	42	F-P	"	.0325	.6724	.0031	.0160	.1999	1.754	.0276	.3814	.5575			Churchill, Canada
	4	F	"	.0252	.7166	.0037	.0366	.1973	1.349	.0269	.5357	.3916			Churchill, Canada
	42	M	*Mouse, Meadow — Microtus pennsylvanicus pennsylvanicus	.0279	.7394	.0046	.0164	.1037	1.312	.0254	.3103	.3984			Willoughby, O.
	53	F-P	"	.0413	.7635	.0042	.0071	.2574	2.250	.0277	.3126	.4099			Willoughby, O.
	10	F	"			.0065	.0305				.4821				Cleveland, O.
7, 11, 12	3	F	Mouse, Mountain Meadow — Microtus alticola alticola			.0018	.0063	.0083		.0235	.233				Arizona
13	1	M	*Mouse, Guatemala — Peromyscus	.0122	.407	.0032	.0126	.1132	1.243	.033	.1477	.22			Arizona
	14	M	"	.0184	.4511	.0014	.0037	.1499	1.186	.0291	.2157	.303			Guatemala
	2	F	"	.0200	.443	.0021	.0049				.2255	.334			Guatemala
	8	F-P	"			.0024	.0064								Guatemala
9	1	M	Muskrat — Ondatra zibethica alba	.900	5.33	.0133	1.43	3.23	21.95	.188	7.45	4.35		176	Churchill, Canada
21A	1	F	Porcupine — Erithizon dorsalum	2.800	30.77	.72	.62	19.75	112.	2.88	26.97	29.88			Maji Moto Camp, Africa
234, 289	2	F	"	2.725	21.22	.361	.337	14.4							Animal Dealer, New York

*Preserved weights.

No.	Sex	Name												Locality
324	M	Porcupine	3.410	19.15	.341	.355	15.5	108		38	27.1			Animal Dealer, New York
81	F	Prairie Dog (*Cynomys gunnissoni gunniensis* (Hollister))			.034	.019				2.72				Seligman, Arizona
84	M	Rabbits, Cottontail (*Silvilagus audubonii*)		5.60	.025	.028				2.564				Seligman, Arizona
93, 94	F	"			.047	.071				6.123				Florence, Arizona
97, 105	M	*Silvilagus audubonii* "		7.25	.031	.094				5.14				Catalina Mts., Arizona
323, 603	M	Rabbits, Flemish giant (*Lepus*)	3.68	10.59	.685	.503	10.57	97.9		24.01				Cleveland
	F	"	2.587	10.14	.403	.662	9.23	82.63		18.3	13.72			Cleveland
80	F	Rabbit, Jack (*Lepus californicus*)		12.00	.147	.256				19.34				Seligman, Arizona
		Rabbits, Wild (*Silvilagus gabbi mesorius* (Goldman))	.439	4.50		.750	2.00	19.50		3.50	4.50	.75		Adult, Panama
16, 45	M	Rat, Mexican pack (*Neotoma*)		2.20	.009	.078				2.56				San Francisco Crater, Arizona
62, 73, 74, 47	F	"		1.87	.014	.056				2.19				San Francisco Crater, Arizona
235	F	Rat, Norway (*Mus norvegicus*)	.197	1.61	.008	.062	730				1.41			Cleveland
701, 704	M	"	.278	2.30	.032	.149	1.61	9.31	.296	3.03	2.29	.82	7.02	Cleveland
	M	Shik-shik (*Citellus parryi paryii* (Richardson))	.878	5.63	.105	.228	5.85	36.27	1.77	7.16	9.87	2.12		Churchill, Canada
	F	"	.958	5.74	.116	.208	5.92	44.83	1.73	7.12	10.57	1.14		Churchill, Canada
64, 63, 22, 18	M	Squirrels, Abert (*Sciurus aberti*)		6.25	.030	.204				3.12				San Francisco Crater, Arizona
		Squirrel (*Sciurus gerrardi morulus* (Bangs))	.287			.300	2.00	11.00		3.00	3.80	.60		Adult, Panama
48	M	Squirrel, Ground (*Callospermophilus*)		3.00	.010	.035				141				Shultz Pass, Arizona

RODENTS—*Continued*

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
78	1	M	Squirrel, Ground... *Citellus tridecemlineatus*	......	2.00	.004	.019	......	...	......	1.09	......	......	......	Seligman, Arizona
23C 23F 23G 28H	4	F	Squirrel, Red... *Sciurus hudsonicus*	.248	5.02	.029	.075	1.82	6.64	.534	1.32	3.17	......	......	Churchill, Canada
23A 23B 23D 23E	4	M	"	.183	4.71	.023	.049	1.57	3.99	.497	1.14	2.66	......	......	Churchill, Canada
633B 633D	2	F	Squirrel, Red... *Sciurus hudsonicus loquax*	.169	4.21	.031	.098	1.23	5.88	.661	1.51	1.34	......	......	Cleveland
633A	1	M	"	.183	3.97	.006	.082	1.511	4.18	.390	1.425	3.25	......	......	Cleveland
633C	1	M	"	.063	4.09	.0056	.025	.545	1.74	.436	.615	1.54	......	......	Juvenile, Cleveland
17 19 23 26 31 32 60	7	F	Squirrel, Red... *Sciurus fremonti mogollonensis*	......	4.30	.009	.079	......	......	......	1.74	......	......	......	San Francisco Crater and Shultz Pass, Arizona
20 21 25 27 28 29 61	7	M	"	......	4.40	.013	.095	......	......	......	1.74	......	......	......	......

UNGULATES

No.	No.	Sex	Name												Locality
677	1	M	Bison, American... *Bison bison*	54.88	334	5.47	6.64	361	695	42.68	256	1190	146	...	Calf, Zoo, Cleveland, O.
79A) 80A)	2	M	Buffalo... *Syncerus caffer caffer*	750 est.	640 est.	34.96	31.05	...	...	...	...	...	...	...	Maji Moto Camp, Africa
45A	1	F-P	" " "	572	642	37.30	43.27	3050	7175	69.94	1625	5150	2304	146000	Maji Moto Camp, Africa
71A	1	M	" "	759	653	38.05	52.40	3620	7709	55.00	1825	8110	...	150000	Maji Moto Camp, Africa
614	1	F	Bushbuck... *Tragelaphus scriptus massaicus*	35.38	140	6.76	4.43	325	625	40.53	131	915	92.75	...	Africa
94A	1	M	" "	53.07	190	5.08	5.09	350	1100	...	225	540	...	6700	Lake Manyara, Africa
652	1	F	Caribou, Barren ground *Rangifer arcticus arcticus*	71.7	278	3.99	2.29	710	466	33.35	82.77	1275	131	...	
44) 653)	2	M	" "	128.47	306	8.37	5.99	1086	2445	41.66	151	2450	310	25400	Tavane and Churchill, Canada
42	1	M	" "	62.14	285	5.98	4.16	650	...	...	...	...	...	...	Chesterfield Inlet, Canada
	1	F	Aberdeen angus...	719	...	57.5	57.50	1950	6690	...	1746	2654	839	21682	
	44	F	Ayrshires...	491	417	33.4	31.2	1882	6010	...	1148	3311	817	25156	
	5	F	Cows...	...	...	11.82	18.07	...	...	...	...	...	...	...	Florida
	6	F	Cows...	...	...	21.03	24.01	...	...	...	...	...	...	...	Cleveland
	62	F	Guernseys...	450	403	31.6	27.7	1737	6087	...	978	3143	832	23523	
	7	F	Herefords...	371	357	15.24	18.46	1143	3819	...	672	2272	561	20734	
	200	F	Holsteins...	574	415	38.1	37.7	2245	7248	...	1445	4336	946	29184	
	6	M	Holstein bulls...	90	299	14.25	6.37	422	...	...	...	...	...	...	Under 6 mos. old
	3	M	Holstein bulls...	241	386	30.2	10.13	998	...	...	...	...	...	...	6 to 12 mos. old
	5	M	Holstein bulls...	552	408	41.4	19.76	1905	...	...	...	...	...	...	1 to 3 yrs. old
	2	M	Holstein bulls...	861	471	45.5	22.5	3243	...	...	...	...	...	...	3 to 5 yrs. old
	5	M	Holstein bulls...	888	462	95.34	41.6	3357	...	...	...	...	...	...	Over 5 yrs.
	218	F	Jerseys...	413	408	27.9	27.4	1605	5747	...	983	3057	801	22230	
	3	M	Jersey bulls...	51.9	304	6.4	5.35	304	...	...	...	...	...	...	Under 6 mos. old

Data from Journal of Agricultural Research V. 55, No. 4, August 15, 1937. W. W. Swett and Associates.

UNGULATES—*Continued*

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
	5	M	Jersey bulls	214	356	19.38	9.78	744							6 to 12 mos. old
	2	M	Jersey bulls	367	384	29.05	14.5	1270							1 to 3 yrs. old
	2	M	Jersey bulls	591	444	47.00	18.3	1987							3 to 5 yrs. old
	10	M	Jersey bulls	597	447	82.20	27.45	2186							Over 5 yrs. old
	213	M	Jersey bulls	412	408	27.90	27.40	1606							Av. 8 yrs. 2 mos.
	71	F	Miscellaneous cows	506	420	35.2	303.3	1888	6786		1207	3978	812	11.1	Cleveland
	6	M	Steers	174		18.8	20.68								Florida
	15	M	Steers	369		13.9	16.57								U. S. D. A.
	18	M	Steers		384	20.87	13.16	1533			423				
1390	1	M	Calf		203.6	4.7	5.2	234.5	505.2	32.6	89.6	294.2	52.9		Full term foetus, Lexington, Ky.
1388	1		Calf	19.5	193.9	8.0	29.4	232	220.5	29.4	106.0	473.2	80.5		Three days old, Lexington, Ky.
1386	1		Calf	233.6	187.9	6.9	4.8	174.2	535.8	25.9	117.4	519.6	69.5		Crossbred, Lexington, Ky.
1389	1		Calf	22.0	215.2	19	32.5	265.3	1008.8	28.7	167.2	737.1	69.1		Six days old, Lexington, Ky.
1387	1		Calf		234.6	12.6	3.0	315.3	792.3	14.3	156.4	581.1	103.5		Lexington, Ky.
1391	1	F	Cow	489.9	473.5	46.1	17.4	2601	6265	69.6	1105.8	6359	729.9		Lexington, Ky.
	2		Deer / *Odocoileus chiriquensis* (Allen)	2.376	54.1	.2	.62	5.16	72		16.5	44.3	5.0		Juvenile, Panama
	1		"	13.93		20	3.0	15.9			55				Adult, Panama
124	1	F	Deer, Axis / *Cervus axis*				8.6		516		280	520	35		India
644	1	M	Deer, Malay Sambar / *Cervus unicolor*	88.45	219	17.5	6.45	749	1730	34.4	247	1726	223		Zoo specimen, Cleveland
277	1	M		148		25	30.6				317				
184) / 181) / 182)	3	M	Deer, White-tailed / *Odocoileus virginianus*			28.3	23.35								Cumberland Island, Ga.

No.	n	Sex	Species	1	2	3	4	5	6	7	8	9	10	Locality
172 }177 }	2	F	Deer White-tailed		210	21.25	12.25	5.1						Cumberland Island, Ga.
		M	" "			23.05	.305	2.57		632	1025		1318	Virginia
272		M	Deer, White-tailed. *Odocoileus couesi*	65.09	123				305	123				Kaibab Forest, Arizona
85 }86 }88 }	3	M	Deer, Mule. *Hemionus odocoileus*		182	5.48				203				Kaibab Forest, Arizona
87	1	F	" "			5.25	2.30	.73		250	21.4			Arizona
27A	1	M	Dik-dik. *Rhynchotragus kirki*	4.57	37	.56	36.8	93.2			44.4			Maji Moto Camp, Africa
568	1	M	Elk. *Cervus canadensis*	13.61	194.2	2.38	131.1	374		73.4	319			Zoo specimen, Cleveland
136	1	F	" "		9.5	8.85				365				Zoo specimen, Cleveland
24 }54 }	2	M	Gazelle, Thomson. *Gazella thomsoni*	24.37	91.8	2.0	245	525	26.6	105	280			Maji Moto Camp, Africa
89	1	F	" "	2.430	54.61	1.04	31.7	60.61	12.35	16.5	74.4		380	Infant, Africa
68A	1	M	Giraffe. *Giraffa camelopardalis vippelskirchi*	1220	700	78.12	4990	19050	127	2268	12060	2266	130000	Africa, Maji Moto Camp
1259	1	M	Goat. *Capra hircus*	27.66	115			525	29.55				1466	Cleveland, O.
53	1	M	Hartlebeest, Coke's. *Bublis cokei cokei*	134	275	9.61	875	1525	56.36	387	1850	625	14540	Moto Umbo, Africa
142A	1	F	Hippopotamus. *Hippopotamus amphibius*	543	540	53.35	1610	14060	35.02	1175	4910		83000	Juvenile, Maji Moto Camp, Africa
143	1	F	" "	1351	720	61.10	4536	23580	42.70	3160	11340	3175	374000	Adult, Maji Moto Camp, Africa
	53*	M	Hogs. *Sus scrofa*	102.06	6.88	4.99	303.5	1488.3		237.83		117.74	1817	Average age, 236 days. Standard bred castrates
	36*	F	" "	102.06	7.52	4.99	324.39	1547.3		264.09		138.64	1988.07	Age 241 days. Standard bred young sows
	30*		" "	102.06	6.46	5.44	297.5	1389.5		246.45		121.71	1667.7	F² crossbred, average 252 days

UNGULATES—*Continued*

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
176) 178)	2	F	Hogs, wild.... *Sus scrofa*	....	....	8.42	2.71	....	....	....	....	....	....	....	Florida
179) 180) 192)	2	M	" "	....	5.31	....	2.69	....	....	....	....	....	....	....	Florida
193) 194) 195) 196)	5	....	Hogs, domestic.... *Sus scrofa*	....	105	14.25	4.16	....	....	....	229	....	....	....	Cleveland, O.
129) 130) 1377) 1378)	2	F	" "	....	....	16.7	3.05	....	....	....	232	....	....	....	Cleveland, O.
1379) 1380) 1381)	5	M&F	Pigs, full term foetuses	1.419	30.3	.45	.27	14.25	43.0	3.29	10.47	25.66	1.96	....	Lexington, Ky.
1383	1	M	Pig, shoat....	4.76	51.2	.7	.37	52.1	184.6	4.05	16.4	49.35	12.5	....	Lexington, Ky.
1382	1	F	Pig, shoat....	13.15	86.2	....	1.75	124.5	392.5	5.1	33.7	205.9	29.0	....	Lexington, Ky.
1384	1	M	Pig, shoat....	....	....	6.6	2.65	147.3	903.8	6.2	65.4	679.1	34.9	....	Lexington, Ky.
1419	1	M	Pig, shoat.... *Sus scrofa*	7.60	54	1.6	2.0	46	284	7.0	54.0	128	14.0	....	Lexington, Ky.
1385	1	F	Pig....	113.2	123.9	10.8	7.8	452	2334.8	7.3	197.5	299.9	173.3	....	Lexington, Ky.
3) 161)	2	M	Impala.... *Aepyceros melanus*	37.86	149	5.67	3.82	270.05	605	44	162.5	510	210	5800	Maji Moto Camp, Africa
13) 2)	2	M	" "	57.61	175	5.04	5.36	378	855	47.12	225	730	....	....	Africa, Maji Moto Camp
198	1	F-P	" "	....	....	5.67	4.62	....	....	....	....	....	....	....	Africa, Maji Moto Camp

No.	n	Sex	Species	29	123.5	125	2.95	174	772	10.2	153	279	65.5	...	Zoo specimen (goiter)
699	1	M	Peccary, Collared.....	13.83		...	4.5	70.5	371	...	51.5	120	91	...	Adult, Panama
......	2	......	*Pecari angulatus bangsi* (Goldman) "	2.25	...		2.0	20	60	...	22	72	10	...	Infant, Panama
	1	M	"												
109	1	M	Peccary.... *Pecari angulatus sonoriensis*	...	82	1.2	1.8				60				Arizona
32)	2	M	Reed Buck (Bohor)....	31.7	109	1.34	2.11	242	523	33.4	102	462	...		Lake Manyara, Africa
33)	9	M.	*Redunca redunca tohi*	40.23	109	10.11	2.22	168			97.06				2500	Bureau of Animal Industry
187 188 189 190 191	5	F	Sheep (Lambs).... *Ovis aries* " "	...	88.8	13.3	2.02				93.1	150			Adult, Cleveland, O.
1397 1398	2	......	Sheep..... *Ovis aries*	2.720	53.8	5.2	3.85	28.30	78.0	13.50	25.8	51.10	10.0		Foetus, 2 to 4 weeks premature. Lexington, Ky.
1395 1399 1401 1403 1404 1405 1407	8	M	Lambs....	6.87	73.6	5.19	6.78	82.13	224.5	18.30	55.8	191.5	17.41		About one mo. old. Lexington, Ky.
1420 1394 1396 1408 1421 1424	5	F	"	8.55	71.5	4.09	6.36	85.0	287.2	13.7	69.5	180.5	27.0		About one mo. old. Lexington, Ky.
1409 1422 1423 1427	4	M	"	15.76	88.6	2.0	3.0	158.7	531.8	17.6	108.3	543.5	36.2		Lexington, Ky.

UNGULATES—Continued

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
1392 1393 1400 1402 1406 1425 1426	7	F	Lambs...........	52.1	106.5	10.2	8.3	276.7	957	30.49	159.8	704.8	119.6	....	Lexington, Ky.
25 141	2	M	Steinbok........ *Raphicerus campestris neumanni*	8.62	49.5	1.22	1.35	72.2	175	14.87	38.51	150	....	550	Africa, Maji Moto Camp
58	1	M	Warthog......... *Phacochoerus aethiopicus*	65.32	125	3.6	8.24	325	1500	17.91	300	550	....	9550	Africa, Maji Moto Camp

UNGULATES—ODD TOED

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
786 789 790	3	F	Thoroughbred foetus.. *Equus caballus*	13.00	183.3	4.18	2.21	111.3	702	....	99	444.3	82.5	....	Average, 91 days, premature. Ky.
....	5	F	" "	26.47	254.4	13.23	14.89	331.5	902.2	37.14	245.0	895.7	139.9	....	Average, 46.4 days, premature. Ky.
....	5	M	" "	27.30	273.9	12.28	4.66	275.9	699.5	51.48	257.4	1374.	162.5	....	Average, 54.4 days, premature. Ky.
....	11	F	" "	47.68	333.9	17.54	8.10	472.	1634.	42.82	321.3	1526.	335.1	....	Average, 14.6 days, premature. Ky.
....	15	M	" foetus.	38.91	317.3	14.80	6.26	458.2	1266.	45.95	275.6	1179.	235.8	....	Average, 16 days, premature. Ky.
....	19	F	" foal.	54.32	366.5	16.80	10.38	606.4	1651.	54.80	405.7	1414.	306.6	....	Average, 5.6 days old. Kentucky

No.	ID	Sex	Class												Remarks
18	....	M	"	52.45	370.1	17.57	9.34	565.	1592.	48.5	323.5	1366.	319.	Average, 3.1 days old. Kentucky
3	1234 1241 815 1236 1244 1246	M	"	93.89	425.3	15.23	14.43	970.	3386.	56.8	859.3	1427.	610.3	Average, 33.5 days old. Kentucky
4	....	F	"	116.77	470.2	22.6	15.20	1125.	3704.	67.5	812.2	2393.	838.5	Average, 83 days old. Kentucky
8	....	M	colts	285.13	582.8	26.55	18.77	1999.7	8193.	71.09	767.7	299.6	1700	Average, 9 months old. Kentucky
2	1231 1349	F	fillys	380.11	616.	36.9	32.3	2653.	3452.	81.5	1168.	2969.5	3379.	Average, 12 mos. old. Kentucky
5	....	M	colts	306.35	602.4	26.81	22.2	2708.	4821.	79.05	970.2	3110.	5494.	Yearling colts. Kentucky
6	....	M	geldings	443.87	637.6	29.41	32.43	3295.	5257.	95.46	1314.	3738.	3845.	Average, 2 to 3 yrs. old. Kentucky
3	1224 666 1351	M	colts	433.92	621.4	26.50	27.71	3488.	3931.	89.90	1297.	3659.	4190.	Average, 2 to 3 yrs. old. Kentucky
7	....	F	fillys	408.5	632.	30.56	38.41	3237.	5350.	98.82	1653.	4588.	3438.	Average, 2 to 3 yrs. old. Kentucky
4	638 1250 1247 1300	M	geldings	446.55	630.	26.99	33.40	3531.	5193.	96.63	1350.	4092.	4830.	Average, 6.75 yrs. old. Kentucky
5	....	M	stallions	485.31	706.7	32.15	33.03	4688.	5685.	106.34	1971.7	7154.	3474.	Average, 17.2 yrs. old. Kentucky
10	....	F	mares	443.36	637.7	29.76	43.5	3663.	6176.	105.0	1667.	4758.	3856.	Average, 19.1 yrs. old. Kentucky
1	684	M	Arabian stallion	461.76	618.	46.80	26.80	3909.	6375.	112.24	1512.	5080.	3000.	27 yrs. old. Portsmouth, O.
1	1287	M	" "	362.80	573.	34.95	42.17	3275.	4670.	108.08	1108.	6475.	1900.	30 yrs. old. Portsmouth, O.
1	1221	F	" mare	199.58	711.4	80.00	....	3230.	....	107.8	....	1462.	507.	Nashville, Tenn. 25 yrs. old.
1	1308	M	Burro gelding	....	392.	13.43	24.2	1184.	3770.	....	844.	....	....	....
2	....	M	Burro	122.98	478.	4.80	16.64	850.	1953.	84.31	813.	1320.	280.	Average, 4 yrs. old. Guatemala
1	707 711	M	Grade Draft	70.76	248.	11.2	7.9	546.	1197.	40.0	230.	916.	524.	Foal, Kentucky
2	1242 659 660	F	Grade Pony	184.16	525	10.49	12.98	1175.	2100.	67.47	420.	1348.	458.	1 year old. Kentucky

UNGULATES—ODD TOED—Continued

Catalogue Number	No. of Animals	Sex	Common and Scientific Name	Body Weight in Kilograms	Brain	Thyroid	Adrenal	Heart	Liver	Eyes	Kidney	Lung	Spleen	Stomach and Intestines	Remarks
604	1	F	Grade Horse	521.64	655.	24.30	52.51	3260.	6920.	105.92	1510.	4125.	1870.		12 years old. Kentucky
1317	1	M	Hackney Pony	362.87	504.	29.6	21.2	1427.							Urbana, Ill.
	10	M	Horses, Panama	279	452	10.77	25.75								Average 12 years. Panama gelding workhorses
	31	F	"	262	468	12.77	25.62		4277		942	3627	940	13542	Average 14 years. Panama mares
	21	M&F	Mules, Panama	230.9	520		35.45	1843							Panama
	3	M	Equus asinus	211	371	8.66	24.6								Average 13.3 years. Panama
	4	F	" "	291	478	9.75	35.5								Average, 20 years. Panama
	1	M	" "	42.64	227		42.53	397	1191		227	628	283	1219	Panama colt
	4	M&F	Mule.	279.2		11.3	47.	2048	3594		513	4026	766	13306	Panama
792	1	F	"	249.47	543.			2144	6301		1049		802.		1 year old. Kentucky
1297	1	F	"	444.52	543.	18.98	45.1	3604.	5342.	124.0	964.	5678.	1802.		25 years old. Kentucky
890	1	M	Percheron Stallion	635.04	662.	40.84	39.22	5600.	8520.	136.7	1700.	5710.	3430.		14 years old. Ohio
691	1	F	Percheron Mare	771.40	650.	56.55	37.40	4700.	6725.	137.4	1750.	5400.	1550.		23 years old. Ohio
635	1	F	Polo Pony	380.75	692.	52.10	24.23	3570.	4835.	115.92	950.	8616.	1250.		25 years old. Ohio
1307	1	F	Pony	376.48	604.	20.02	28.00	2607.	5012.	96.5	1894.	2558.	3846.		18 years old. Kentucky
791	1	F	Saddle-bred foetus	19.50	226.	7.2	2.6	181.5	913.			1038.	141.		71 days premature. Kentucky
1245	1	F	Saddle-bred foal	118.8	475.	12.8	10.2	894.	2796.	56.0	735.		536.		3 months old. Kentucky
1296	1	F	" weanling	181.4	492.			1418.		64.0		2981.			6-7 months old. Kentucky

No.		Sex	Animal												Remarks
800, 1203	2	M	Sabble-bred colts	300.5	588.	18.43	17.33	1658.	4397.	87.55	1033.	3457.	1079.	......	1 year old. Kentucky
1239, 1305	2	M	" geldings	335.68	569.	16.95	20.70	2199.	4616.	84.48	929.	3189.	2010.	......	1 year old. Kentucky
1348	1	M	Shetland Pony gelding	242.67	560.	15.25	23.5	2195.	3975.	104.0	870.	3740.	1380.	......	29 years old. Kentucky
803	1	F	Standard bred foetus	31.75	242.	11.9	6.7	402.	1052.	......	196.	921.	84.	......	About 60 days premature. Kentucky
1240	1	M	Standard bred foal	92.98	400.	14.6	10.1	971.	2400.	69.0	624.	1489.	330.	......	3 months old. Kentucky
636	1	F	Hunter(Thoroughbred)	402.65	690.	24.45	47.32	3648.	5220.	112.6	1200.	10,120.	1760.	28,110.	15 years old. Ohio
693	1	M	Western gelding	426.38	562.	25.59	35.37	3487.	5338.	107.0	1196.	4005.	5750.	......	23 years old. Ohio
8A	1	M	Rhinoceros...... / Rhinoceros bicornis	763	655	53.05	88.0	4800.	14310	22.56	3000	7350	......	......	Maji Moto Camp, Africa
......	1	......	Tapir / Tapirella bairdii (Gill)	8.60	......	......	2.0	74	220	......	92	162	84.	......	Juvenile, Panama
......	1	......	Zebra...... / Equus quagga granti	14.26	85	......	3.0	121	483	......	167	318	172	......	Adult, Panama
686	1	M	" "	29.48	......	14.77	6.24	330	937	39.5	90.54	655	135.8	......	Foetus, Zoo
35A	1	M	" "	7.900	125	3.04	1.43	75	275	......	53.65	300	......	......	Embryo, Africa
634	1	F	" "	43.09	412	29.2	9.6	581.8	1275	......	166.4	740	156.1	......	Infant, Zoo
179A	1	F	" "	56.59	410	10	4.95	515	950	......	262	1025	605	......	Six weeks old, Africa
626	1	M	" "	78.02	494.4	48.6	11.5	660.4	4037	94	357.3	2025	1170	......	Zoo
20A	2	M	" "	254.99	541	20.08	23.08	1925	......	......	855	......	......	......	Stallion, Africa
160A, 162A	1	F-P	" "	297.1	555	17.34	27.8	1970	4400	89	900	2790	......	......	Africa
698	1	M	" "	317.5	642	36.0	44.1	2231	6336	103	1239	......	1121	......	Jungle-bred Stallion six yrs. old. Zoo

PROBOSCIDEA AND HYRACOIDEA

No.		Sex	Animal												Remarks
148A	1	M	Elephant. / Loxodonta africana knochenhaueri	6654	5712	800	940	28080	107670	116.15	18180	138790	......	924000	Maji Moto Camp, Africa
	1	F	Elephant, Pygmy. / Loxodonta cyclotis	......	......	......	84	......	......	......	5200	......	......	......	Zoo
149A	1	M	Hyrax. / Heterohyrax brucei	.750	12.27	.081	.161	3.63	31.53	......	6.45	5.532	......	255	Lake Manyara, Africa

BOOK NOTICES

The Biology of Man

Two facts have become increasingly apparent to teachers of college biology in recent years; first, many modern college students are better equipped in biological courses upon entering college than were students in former days, and second, college students show far greater interest in the biology of human beings than in that of lower organisms. These facts lead to important problems for the college teacher. He must see that the introductory college course reaches a higher level than that of the high school, so as not to dull the students' interest by needless repetition. He must fit into the college course more complex and advanced material, and at the same time keep or even increase the interest of the student.

Dr. Baitsell has taken a noteworthy step in this direction by preparing an excellent introduction to biology, built around the organization and activities of human protoplasm. While the interest of the student is kept up by the human approach, comparative biology is not neglected. It is introduced where and when needed, however, and is not forced upon the student. The book is beautifully written, clearly presented, and well illustrated. It deserves a thorough trial in the introductory course, and should meet with marked success. Especially valuable are the excellent summarizing chapters such as that on The Web of Life, and the unique appendix, which is full of material which the better student will read avidly.

Two adverse comments may be made. The beginning student, it is feared, will develop a teleological viewpoint from the reading of the book unless the teacher is careful to circumvent it. The references to figures are always placed at the ends of the paragraphs dealing with such material, although the concluding sentence of the paragraph frequently has no bearing on the figure.—*L. H. S.*

Human Biology, by George A. Baitsell. xv+621 pp. New York, the McGraw-Hill Book Co. 1940. $3.75.

"Adventures"

The experiences of the scientist certainly may be described as adventures, not in the sense of mere thrills but as journeys into the unknown from which he may return with great treasure or seemingly empty handed. In exploring the mysteries of physiology, Haldane has not hesitated to use himself as an experimental animal; breathing carbon dioxide or taking ammonium chloride to test the effects upon the pH of the blood; sitting in a pressure tank in which conditions in a sunken submarine were reproduced in order to be able to give accurate evidence in court. These are but a few of the "adventures" which the author recounts.

The book is composed of a series of essays, lectures and radio addresses upon such topics as: Unsolved Problems of Weather, Earth, Sun, Life, Race, Health; What Is Life?; What Is Death?; Keeping Cool; Darwin; Protoplasm; Human Biology and Politics; Why I Am a Materialist; Religious Liberty; The Marxist Philosophy; etc. These were written at different times, hence there is a decided lack of unity which there is no attempt to disguise. Rather than a defect, this discontinuity is of advantage to the reader, for the book may be picked up and a single chapter read now, another one later, without danger of losing the thread of the narrative.

Haldane summarizes our scientific knowledge in particular fields and unhesitatingly predicts the state of knowledge thirty or fifty years hence. More than this, he does not recoil from stepping into the fields of politics and philosophy to render his opinions.

The chapters dealing with scientific topics are usually packed with interest whereas a departure into politics and Marxian philosophy in the latter chapters of the book tend to "let one down."

The reader may not agree with the writer's course of action in politics nor the philosophy endorsed, but cannot refrain from admiring such a courageous character.—*P. E. Schaefer.*

Adventures of a Biologist, by J. B. S. Haldane. 281 pages. New York, Harper and Brothers. 1940. $2.75.

LIMNOLOGICAL STUDIES OF BUCKEYE LAKE, OHIO[1]

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The State of Ohio contains only a few small lakes and of these, one of the most important from a fishing and recreational standpoint is Buckeye Lake, located approximately thirty miles east of Columbus. In the summer of 1930 the Division of Conservation of Ohio sponsored and financed an intensive study of this lake under the direction of Mr. E. L. Wickliff, Chief of the Bureau of Scientific Research. The following account deals with the chemical, physical and hydrographical features of the lake and with its contained microscopic life. Investigations were carried out during the period between June tenth and September tenth, 1930. The senior author is responsible for the collection of plankton samples and for the chemical, physical and zooplankton parts, the second author determined the phytoplankton and the junior author the bottom organisms. Samples of bottom organisms were collected by Mr. Lewis Roberts while the zooplankton counts were made by Mrs. E. C. Tressler, who also assisted in the routine work of the laboratory. Dr. E. B. Ruth and Mr. Wilbur Titterington assisted with the identification of bottom organisms. The authors wish to acknowledge with appreciation the assistance of Mr. David Wickliff who greatly furthered the work of the laboratory by his interest in the investigations and in the loan of boats and equipment.

THE LAKE

Detmers (1912) gives the following description of the location of Buckeye Lake: "Buckeye Lake is situated in Licking, Fairfield and Perry counties in ranges 17 and 18, townships 17, 18, and 19. It is a long irregular body of water with its longest

diameter from east to west extending from 82° 25' 27" to 82° 31' 12" west longitude, approximately 7⅛ miles from east to west and varying in width from one fourth mile in the eastern portion to a mile and one half at the extreme western end and covering an original estimated area of 4,200 acres (1,700 hectares). Originally used as a reservoir for the Ohio Canal, on May 21, 1894, the General Assembly of Ohio passed an act reserving the reservoir for a public park and summer resort known as Buckeye Lake.

"The site of the lake was a more or less completely tree-covered, impassable swamp. It lay diagonally across the southeast corner of township 17 and almost half across the southern border of township 19. In the center of this area was a long, narrow lake fed by several small streams of which the largest were Buckeye and Honey creeks. The lake drained into the south fork of the Licking River."

The drainage belongs to two systems, the Licking-Muskingum and the Scioto River systems. The principal streams feeding the lake are Buckeye and Honey creeks and the southwest feeder, although there are numerous smaller streams. The main outlet is the overflow near Buckeye Park.

Buckeye Lake has a maximum depth of seven meters and a mean depth of two and a half meters. In only two places does the maximum depth exceed four meters and these are of very limited area. The bottom is, with few exceptions, of a muddy character, although in some places where dredging has been recently done, there are some sand and gravel. The whole lower, eastern portion ends in a large swamp area through which a channel has been dredged to Thornport. There are also large areas of swamp in Honey Creek, Buckeye and Maple Swamp sanctuaries (see Figure 1, which gives the principal weeded and swampy areas). Extending from Seller's Point to Onion Island is the remains of the old tow path, the middle wall of which comes to within half a meter or less of the surface. Winds which sweep down the lake at times cause large waves which thoroughly stir up the entire lake and aid in keeping the water turbid.

METHODS

Weekly readings were made at two stations on the lake, one at a spot directly in front of the laboratory (station 1) where the water was between 2½ and 3½ meters deep, another in the
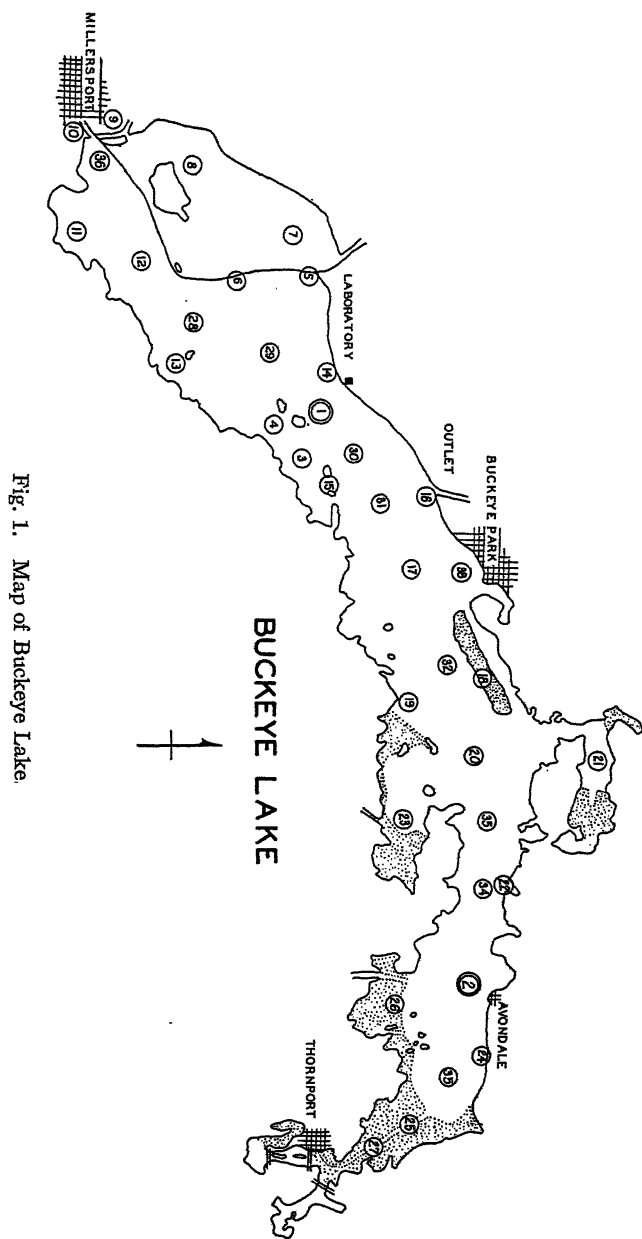
Fig. 1.   Map of Buckeye Lake.

deep area off Avondale at the eastern end of the lake (station 2) where five to six meters could be counted on. At station 2, samples were taken at the surface and near the bottom as well but at all other stations surface samples only were secured. Surface samples were taken at a depth of between fifteen and twenty-five cm. Other stations at various points on the lake are shown in Figure 1. Horizontal variation in plankton and environmental factors was investigated on two occasions and a twenty-four-hour series was made to determine diurnal variation.

Temperatures were taken with a Negretti-Zambra deep-sea reversing thermometer and transparency by means of a 10 cm. Secchi disc. Color determinations were made with the standard platinum cobalt solution as recommended by the American Public Health Association (1925). Silica was determined according to Atkin's modification (1923) of the method of Dienert and Wandenbulke (1923) and phosphorus by Atkin's method (1923). Other chemical procedures followed methods recommended by the American Public Health Association (1925) or by Birge and Juday (1911). Water samples for chemical analysis and for plankton were obtained by means of a Kemmerer-Foerst water sampler. One liter of water was centrifuged with a Foerst centrifuge and the plankton obtained was made up to 20 cc. for phytoplankton counting. Duplicate samples of one liter each were also centrifuged and particulate organic matter determined by loss on ignition. Three liter samples of lake water were evaporated to determine the total amount of dry residue. A ten-liter Juday-Foerst plankton trap was used to collect zooplankton and an Eckman dredge 20 cm. by 20 cm. was employed in the collection of bottom samples.

<div align="center">RESULTS OF PHYSICAL MEASUREMENTS</div>

Temperature.—Temperatures at station 1 are shown in Figure 2. The temperature of the water rose steadily as the summer progressed until a maximum was reached about the last of July or the first of August. In Figure 2, air temperatures are shown by the wavy line superimposed on the water temperature curve. These temperatures represent the approximate daily maximum air temperature at the laboratory. It will be noted that while the temperature of the water followed the general trend of the air temperature, there were no sudden changes. A maximum of 29.0° C. was observed on August 5, at station 1. The maximum at station 2, at the eastern end of the lake, was 28.6° C. which occurred on July 29. At station 19, on July 30, a maximum of 30.2° C. was noticed, while on July 12, at 4 p. m. three inches below the surface at a spot about 30 meters off the laboratory, a maximum temperature of 31.0° C. (88° F.) was recorded. The temper-

ature probably reached somewhat higher figures but these were the maxima recorded. The minimum temperature at station 2 was 20.4° C. which occurred on August 26, while the minimum at station 1 was 21.1° C. on August 22. The surface water was considerably cooler at the extreme eastern end of the lake in the channel between the marsh areas.   On July 17, at station 27, a temperature of 21.0° C. was noted, which was over six degrees lower than the temperature taken a few minutes later at station 24 in the open waters of the lake where the temperature was 27.6° C. These low temperatures were correlated with high transparency and were possibly due to the protection given by
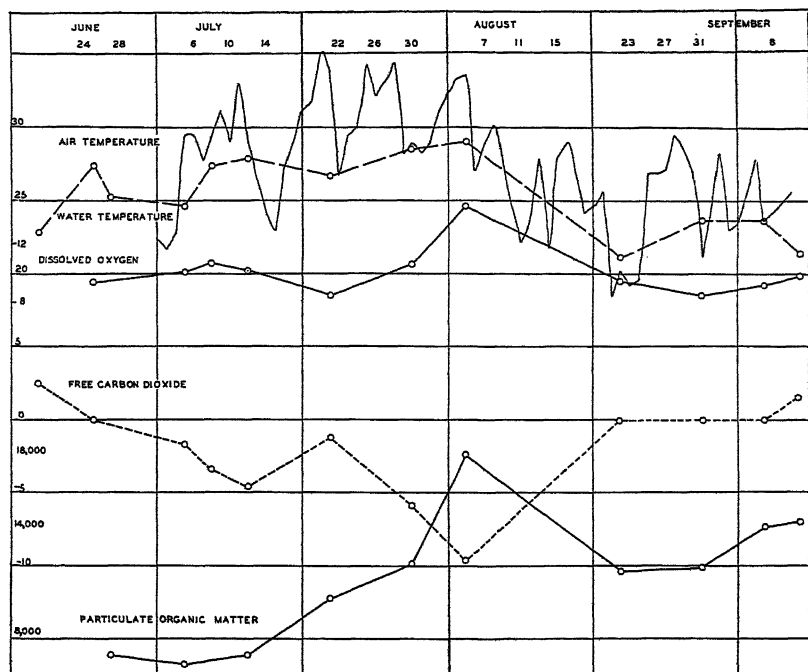
Fig. 2.   Summer fluctuations of physical and chemical factors and particulate organic matter at station 1. Temperatures are shown in degrees Centigrade, chemical factors in parts per million, organic matter in milligrams per cubic meter.

the rooted aquatics both from the sun and from wave action and stirring up of bottom water.

In general the temperatures at the eastern station followed those taken at station 1. The maxima and minima occurred at about the same time, although minor fluctuations did not always agree. The maximum amount of vertical stratification in temperature was noticed on June 14, at station 2, where the surface water showed a temperature of 25.6° C., while the water at 6.25 meters depth was 18.6° C.

Transparency.—The waters of Buckeye Lake are of very low transparency. The maximum reading taken with the Secchi disc was only

0.75 meters at station 1. The readings at station 2 were always lower than at station 1 and both stations showed a decline in transparency as the summer progressed, station 1 declining to a transparency of 0.3 meters by the end of the summer. When it is considered that an ordinary lake will show transparencies of from three to 10 meters or more and that the maximum transparency recorded for a lake amounts to 41 meters (Lake Masyuko in Japan), the extremely low transparency of Buckeye Lake may be appreciated. Lakes which are on the average much shallower than Buckeye often have transparencies of from 1 to 3 meters. The low transparency in Buckeye Lake is due to several factors: the enormous phytoplankton crop during the summer, the action of the wind in stirring up the bottom sediments and the amount of organic matter present in the water. On standing for two or three days, the lake water would clear up remarkably, the supernatant liquid showing little color, so that this factor was not important in this instance. In the swamp areas, where the wind had little effect, the readings were considerably higher. At station 27, transparency reached a maximum of 1.75 meters but as this was also the depth of the water at this place, the transparency was undoubtedly considerably greater, since the disc could be clearly seen on the bottom. In the lake itself, these figures were never approached.

Color.—The color of the water after filtering (true color) was about 25 on the platinum-cobalt scale. This is not at all high; many lakes in northern Wisconsin will show colors as high as 200 or 300 units on this scale. The absence of bog waters or of inflow from such regions accounts for the low color of the water of Buckeye Lake.

RESULTS OF CHEMICAL ANALYSIS

Dissolved Oxygen.—The seasonal variation of dissolved oxygen at station 1 is shown in Figure 2. In most lakes, oxygen becomes reduced during the summer months due to the inability of water of higher temperature to hold as much gas in solution. In Buckeye Lake, however, oxygen increased with the increase in temperature and its maximum amount coincided with the period of maximum temperature. This unusual condition was due to the enormous crop of phytoplankton which increased to a maximum at the same time. The greatest amount of dissolved oxygen recorded during the summer was found at station 1 (14.6 p.p.m. on August 5, 188% saturation). The highest figure for station 2 was 12.8 p.p.m. on August 26. On August 26, station 2 also showed the high figure of 11.6 p.p.m. (148% saturation). The minimum oxygen tension observed at station 2 occurred on July 29, at a depth of 5 meters. Here only 1.9 p.p.m. was present, due to decomposition of bottom debris. The bottom waters were never completely saturated during the summer at this station and were usually between 50% and 75% saturated. On July 29, the bottom water was only 23% saturated. In a bog hole on Cranberry Island, the lowest oxygen tension was recorded (1.4 p.p.m., or 15% saturation).

Carbon Dioxide.—Figure 2 indicates summer variation of free carbon dioxide at station 1. Station 2 showed essentially the same

changes. Station 1, however, had a much more even curve than station 2, due to the fact that at station 2 carbon dioxide was constantly replaced by decomposition in the deep hole. High winds mixed the lake from surface to bottom, thus bringing up the accumulated carbon dioxide from the deep hole. For this reason free carbon dioxide was observed at the surface at station 2 as late as July 22, while none was observed during the months of July or August at station 1. The times of minimum free carbon dioxide will be noted to have occurred at the same period as maxima for temperature, oxygen and organic matter. The activity of the lake was at its height at this time in early August. On August 5, the greatest deficiency of free carbon dioxide observed anywhere on the lake occurred at station 1 (9.7 p.p.m.). (That is to say, 9.7 p.p.m. of carbon dioxide would be required to make the water neutral to phenolphthalein). On August 27, a maximum amount of 31.0 p.p.m. was noted in the bog hole on Cranberry Island. The maximum amount observed in the lake itself was at station 2, at 5 meters on August 26, (9.0 p.p.m.).

Fixed carbon dioxide, determined as methyl orange alkalinity, showed some increase as the summer progressed (from 87.2 p.p.m. on June 19, to 95.5 p.p.m. on September 10, at station 1). Station 2 showed an increase of about the same order of magnitude (86.3 on June 28, to 96.5 on August 6). These figures show the waters of Buckeye Lake to be "hard" and largely account for the superabundance of phytoplankton forms.

Hydrogen Ion.—The pH in a general way varied inversely as the free carbon dioxide. The neutral point for free carbon dioxide, however, did not agree very closely with the pH value at the same time, due to the presence of buffers in the water which prevent any sudden change in the pH. The maximum pH observed for the lake was 8.9 on August 5, at station 1. The lowest pH recorded in the lake was 7.3 on July 6, and August 26, at a depth of 5 meters at station 2. Station 1 varied between pH 8.2 and pH 8.9 during the summer. On August 27, at the Cranberry Island bog hole, a pH of 6.8 was recorded. Dachnowski (1939) recorded a minimum pH of 4.0 for certain parts of this bog.

Chlorides.—Determinations of chlorides were made during most of the summer but only a trace was ever observed when correction for the blank on the reagents had been made. This lack of chlorides is due to the freedom from pollution which Buckeye Lake enjoys, a fact also borne out by the low nitrite nitrogen figures.

Nitrogen.[2] Free ammonia nitrogen was present to a maximum amount of 0.146 p.p.m. observed on July 30, at 5 meters at station 2. The remainder of the determinations showed figures ranging from a trace to 0.130 p.p.m., the latter amount occurring in one of the sanctuaries. Ammonia steadily decreased throughout the summer. The same decrease was noted in a shallow Wisconsin lake (Tressler and Domogalla, 1931) and is probably due to the increase in the activity of the denitrifying bacteria in the warmer water. In Buckeye Lake,

ammonia nitrogen had fallen to 0.006 p.p.m. at stations 1 and 2, while at other stations only a trace remained.

Tests for nitrite nitrogen were made from time to time but indicated either none at all or a trace, which shows the lake to be largely free from sewage pollution.

Organic nitrogen increased somewhat throughout the summer due to the increasing amount of plant material in the lake. On June 26, the surface waters showed 0.470 p.p.m. of organic nitrogen, while on August 21, this had increased to 0.704 p.p.m. Nitrates showed the result of large amounts of plant material in the lake which use up this form of nitrogen. Amounts ranged from somewhat greater than 1.00 p.p.m. to 0.050 p.p.m. The lower figures were observed toward the end of the summer.

Silica.—Dissolved silica in the water ranged from 1.6 p.p.m. to 8.0 p.p.m. Dissolved silica is low in summer due to its utilization by the diatoms in building their shells (Birge and Juday, 1911). There was little rainfall during the summer to add to the amount of silica and this also tended to keep the amount low (Pearsall, 1923).

Phosphorus.—A few determinations of soluble phosphorus showed results ranging from a trace to 0.400 p.p.m., the high amount occurring in one of the sanctuaries. The surface waters of the lake gave an average soluble phosphorus content of about 0.030 p.p.m. The data are insufficient to draw any conclusions as to the summer variation, although determinations made when the activity of the lake was at its height, showed higher figures for both stations 1 and 2 than later in August. The great numbers of plant organisms evidently caused this depletion.

<div align="center">THE ZOOPLANKTON</div>

Ten liters of water collected with a Juday-Foerst plankton trap were reduced to 20 cc. and two 1 cc. samples were counted for zooplankton forms. Results were expressed as the number of organisms per cubic meter.

Buckeye Lake does not support a great variety of zooplankton forms; only seventeen species belonging to sixteen genera were found during the summer. Of these there were two species of copepods, nine of Cladocera and six rotifers. The complete list of species identified during the summer of 1930 is given below.

<div align="center">Copepoda</div>

Cyclops viridis americanus Jurine   *Ergasilus versicolor* Wilson

<div align="center">Cladocera</div>

Alona quadrangularis (Müller)   *Daphnia retrocurva* Forbes
Bosmina longirostris (Müller)   *Daphnia* sp.
Camptocercus rectirostris Schoedler   *Leptodora kindtii* (Focke)
Ceriodaphnia sp.   *Pseudosida bidentata* Herrick
Chydorus sphaericus (Müller)   *Sida crystallina* (Müller)

Rotifera

Brachionus bakerii Ehrenberg   *Polyarthra trigla* Ehrenberg
Conochilus sp.   *Rattulus styalatus* (Gosse)
Diglena sp.   *Synchaeta* sp.

Miscellaneous

Cypria dentifera Sharpe   *Hyalella* sp.
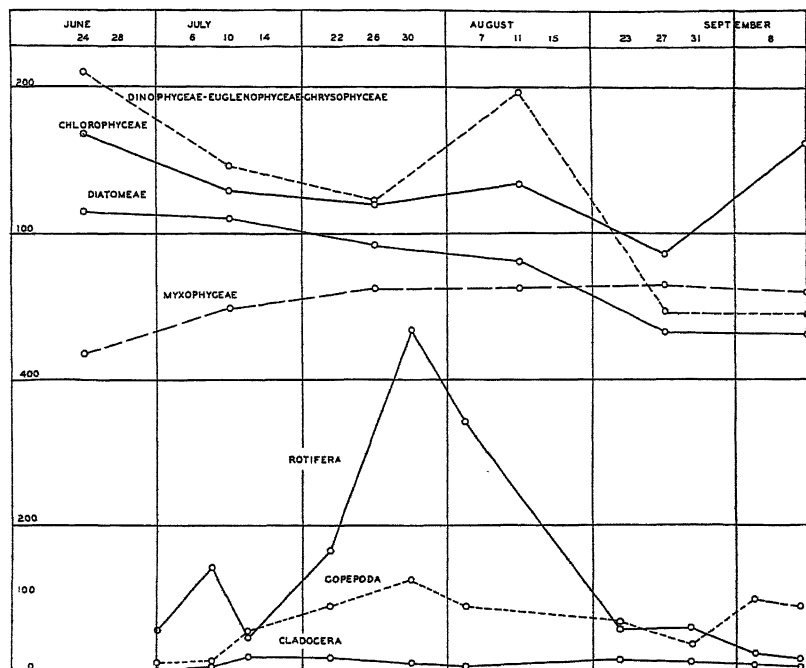
Fig. 3. Summer fluctuations of plankton groups. Phytoplankton is shown as the average number of organisms, in thousands per liter, during each of the two-weeks periods; zooplankton as the average number of organisms per liter.

Summer Fluctuations.—Figure 3 indicates the summer distribution of the various groups of zooplankton at station 1. It will be noted that the time of maximum abundance of the copepods and rotifers was during the midsummer slightly before the period of maximum activity of the lake. Cladocera were never very abundant at any time and appeared in greatest numbers about the middle of July. At station 2 the Cladocera showed very slight fluctuations during the summer. In the weedy areas of the lake there were large numbers of cladocerans but these were forms restricted to such environments and were never found in the limnetic region. The most abundant limnetic cladoceran was

Pseudosida, the summer distribution of which is shown in Figure 4. This cladoceran never exceeded 20,000 individuals per cubic meter. Immature Cladocera were found during the early part of the summer but disappeared after the first week in August from the samples at station 1. The large form, *Leptodora kindtii* was very abundant at the first part of the summer but was seldom taken in the counts, due in all probability to its ability to see and avoid the trap and smaller tow nets. A tow made with a meter net in July showed a pure culture of this large cladoceran in large numbers. The only abundant copepod was *Cyclops,* which was present in fairly large numbers during the entire summer and reached a maximum at one meter depth on August 6, at station 2 (196,000 per cubic meter). At station 1 *Cyclops* had maxima on July 21, (60,000 per cubic meter) and on September 10 (68,000 per cubic meter). Nauplii were found throughout the entire summer in considerable abundance. At station 2, nauplii reached their maximum on September 4, (132,000 per cubic meter) and had shown a steady increase in numbers from the beginning of the summer. At station 1 they were most abundant during July and showed no regular increase during the summer. Of the rotifers, by far the most abundant was *Brachionus bakerii,* which reached a maximum at station 1 on July 30, of 578,000 per cubic meter and was present in large numbers during the entire summer. The summer distribution of some of the other rotifers which were more or less abundant is shown in Figure 4.

Vertical Distribution.—Buckeye Lake is so shallow, even at the deepest part off Avondale, that vertical distribution of zooplankton is of very little significance. There is no thermocline to effect distribution and conditions, except in the case of light, are very much alike from surface to bottom. On rough days one expects to find few animals at or near the surface and the same is true on very bright days. At station 2, the greatest number of organisms occurred at 1 meter depth at all times during the summer with two exceptions, on July 14, which was a cloudy day, the number at the surface exceeded those at 1 meter. On August 18, however, there were more organisms at the surface on a clear sunny day. No explanation is offered for this anomaly of distribution. At station 1, with the exception of the first few observations in July, there were always more copepods at the 3 meter level than at 1 meter. The total number of organisms at station 1, was at most times greater at 1 meter than near the bottom, due to the greater proportion of rotifers in the upper layers.

Horizontal Distribution.—On July 28, a clear sunny day, with no wind, a series of fifteen stations were sampled starting at the western end of the lake and continuing to the eastern end. These samples were taken with the trap at a depth of ¾ meters and between the hours of ten a. m. and noon, so as to avoid differing light intensities. The results indicated a very uneven distribution of organisms, as has been shown on other lakes. Swarming, wind action and other factors play a part in this unequal horizontal distribution of the plankton. Small lakes, with even bottom contours, have been shown to show a fairly regular horizontal distribution of plankton. Buckeye Lake, however, has many islands and is of irregular shape.
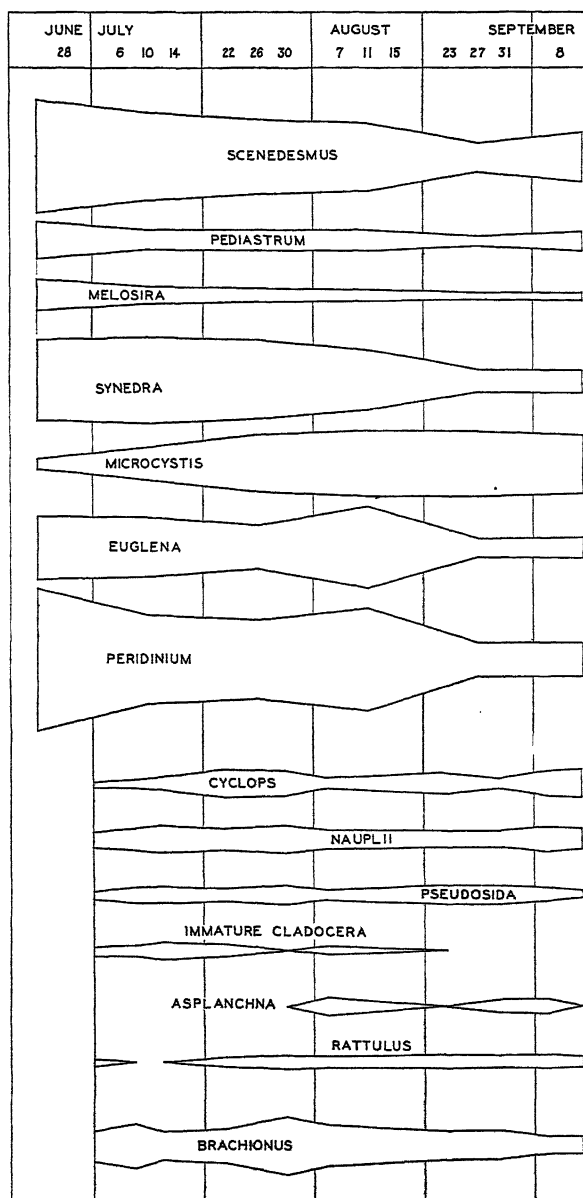
Fig. 4.   Summer fluctuations of some of the more abundant genera of plankton organisms.   Phytoplankton is shown as the average number of organisms per liter during each of the two-weeks periods; zooplankton as the average number of organisms per cubic meter.

PHYTOPLANKTON

A liter sample of water was collected in the Kemmerer-Foerst water sampler and run through a Foerst centrifuge to obtain the smaller organisms. Each centrifuged sample of plankton was made up to a constant volume (usually 20 cc.). After thorough shaking and mixing of the contents of the sample, one cubic centimeter of the material was withdrawn by a pipette and transferred to a Sedgwick-Rafter cell for counting. Ten random counts from each of two transfers from the sample were made, thus securing twenty counts for each liter sample. The number of algal organisms per liter of sample was then computed and recorded.

A number of stations were established for the survey from which collections were made regularly in some cases and intermittently in others.

In order to be able to make numerical comparisons among numbers of organisms counted, it is necessary to select some standard units. At best, these units can be only approximate in their comparative value and to a certain extent must be arbitrarily chosen. Perhaps some approximation on the basis of gross size furnishes a fairly usable unit. It is almost impossible to make comparisons with the data secured by other workers in cases where no mention is made of the kind of unit used in counting. In this report each unicellular alga is counted as one, regardless of size. Rather definite colonies, such as *Pediastrum*, *Scenedesmus* (4-celled), *Coelastrum*, *Oocystis* and *Microcystis*, are counted as units also in spite of the fact that the number of cells in different colonies varies considerably. The filament forms of varying lengths and sizes and the indefinite colonial forms are the most difficult to enumerate satisfactorily. For some filamentous forms a convenient space on the counting cell was arbitrarily chosen as a unit, the length depending upon the individual cell length of the filament.

The arbitrarily chosen units for some of the filamentous and colonial forms are as follows: *Melosira* 300 μ, *Oscillatoria* 300 μ, *Lyngbya* 300 μ, *Anabaena* 300 μ, *Aphanizomenon* 300 μ, *Dinobryon* 5 cells, *Merismopedia* 16 cells, *Crucigenia* 8 cells.

The following list represents all the algae that could be identified definitely to species. Some occurred very rarely and in too small numbers to enter into the computation of prevalent algae during the survey. In some cases identification was uncertain and such forms are listed merely as "spp."

Chlorophyceae

Actinastrum hantzschii Lagerh.
Ankistrodesmus falcatus (Corda) Ralfs
Closterium acerosum (Schr.) Ehr.
C. acutum Breb.
C. ehrenbergii Menegh.
C. kuetzingii Breb.
C. pronum Breb.
Coelastrum microporum Naeg.
C. sphaericum Naeg.

Cosmarium granatum Breb.
C. radiosum Wolle
C. spp.
Crucigenia emarginata (W. and G. S. West) Schm.
C. rectangularis (Naeg.) Gay
Lagerheimia citriformis (Snow) G. M. Smith
L. genevensis Chodat var. subglobosa (Lemm.) Chodat
L. subsalsa Lemm.
Micractinium pusillum Fres.
Oocystis borgei Snow
Pandorina morum Bory
Pediastrum biradiatum Meyen
P. boryanum (Turp.) Menegh.
P. duplex Meyen
P. simplex Meyen
P. tetras (Ehr.) Ralfs
Pleodorina illinoisensis Kofoid
Pleurotaenium coronatum (Breb.) Rabenh.
P. trabecula (Ehr.) Naeg.
Scenedesmus acuminatus (Lagerh.) Chodat
S. armatus (Chodat) G. M. Smith
S. bijuga (Turp.) Lagerh.
S. denticulatus Lagerh.
S. dimorphus (Turp.) Kuetz.
S. obliquus (Turp.) Kuetz.
S. quadricauda (Turp.) Breb.
Schroederia setigera (Schroeder) Lemm.
Selenastrum bibraianum Reinsch
Sorastrum spinulosum Naeg.
Spondylosium papillosum W. and G. S. West
Sphaerocystis schroeteri Chodat
Staurastrum spp.
Tetraedron enorme (Ralfs) Hansg.
T. minimum (*A. Br.*) Hansg.
T. muticum (A. Br.) Hansg.
T. regulare Kuetz.
Treubaria varia Tiffany and Ahlstrom
Trochiscia aspera (Reinsch) Hansg.
Volvox globator L.

Myxophyceae

Anabaena circinalis (Kuetz.) Rabenh.
A. flosaquae (Lyng.) Breb.
Aphanizomenon flosaquae (L.) Ralfs.
Chroococcus minutus (Kuetz.) Naeg.
C. turgidus Naeg.
Coelosphaerium kuetzingianum Naeg.
Gloeotrichia natans (Hedw.) Rabenh.
Lyngbya aestuarii (Mert.) Liebm.
L. major Menegh.
Merismopedia elegans A. Br.

M. glauca (Ehr.) Naeg.
M. tenuissima Lemm.
Microcystis aeruginosa Kuetz.
M. flosaquae (Wittr.) Kirch.
M. marginata (Menegh.) Kuetz.
Nostoc linckia (Roth) Born.
Oscillatoria limosa Ag.
O. princeps Vauch.
O. tenuis Ag.
Phormidium retzii (Ag.) Gom.

Diatomeae

Asterionella gracillima (Hantz.) Heib.
Caloneis trinodis (Lewis) Boyer
Cocconeis placentula Ehr.
Cymbella affinis Kuetz.
C. ventricosa Kuetz.
Fragilaria capucina Desm.
Gomphonema constrictum Ehr.
G. parvulum (Kuetz.) V. H.
Gyrosigma acuminatum (Kuetz.) Cleve
Melosira crenulata (Ehr.) Kuetz.
M. distans (Ehr.) Kuetz.
M. varians Ag.
Meridion circulare (Grev.) Ag.
Navicula cryptocephala Kuetz.
N. cuspidata Kuetz.
N. lanceolata Kuetz.
N. radiosa Kuetz.
N. spp.
Nitzschia linearis W. Smith
Surirella splendida (Ehr.) Kuetz.
Synedra pulchella (Ralfs) Kuetz.
S. ulna (Nitz) Ehr.
Tabellaria fenestrata (Lyng.) Kuetz.

Euglenophyceae

Euglena oxyuris Schm.
E. spirogyra Ehr.
E. spp.
Phacus longicauda (Ehr.) Duj.
P. pleuronectes (O. F. M.) Duj.

Dinophyceae

Ceratium hirundinella (O. F. M.) Schrank
Peridinium spp.

Chrysophyceae

Dinobryon sertularia Ehr.
Synura uvella Ehr.

PERIODICITY AND RELATIVE ABUNDANCE

Transeau (1916) established the class "ephemerals" for the plankton algae collected in his survey of the ponds and streams of Illinois. Taking the organisms as a whole, he found plankton species most abundant in May and June, with a lesser maximum in October. The reports of Birge and Juday (1922) for Wisconsin, Burkholder (1929, 1930) for eastern Lake Erie, Muenscher (1928, 1930) for New York and unpublished data for western Lake Erie all indicate rather definite plankton periodicity in large bodies of water. Eddy (1927) has reported monthly abundance of some plankton forms in small lakes in central Illinois. It is unfortunate that the survey of Buckeye Lake did not extend through a longer period, from the standpoint of data for periodicity. It will not be possible to make definite comparisons with previous workers because of the limited season covered in this survey.

In reporting the periodicity of phytoplankton in Buckeye Lake, the time covered by the survey has been divided into periods of two weeks. The first half and the last half of each month are used arbitrarily as the two-weeks periods and the number of individuals is recorded for each period (Figures 3 and 4). The connecting lines in the graphs do not represent actual gradations between successive periods: they merely connect successive two-weeks enumerations. It is interesting to note that as a whole the Chlorophyceae are more abundant in June and September, corresponding to Transeau's findings for Illinois (*supra*). The Diatomeae begin with a maximum in June, gradually decreasing to a minimum in early September. The Myxophyceae show an early minimum in June with a maximum in July and August. The Dinophyceae-Euglenophyceae-Chrysophyceae group (including the genera *Peridinium, Ceratium, Euglena, Phacus, Dinobryon* and *Synura* and for convenience considered here as a single class) show two maxima: one in June and the other in early August, with a marked drop to a minimum in late August and early September.

The periodicity of a few common genera (*Synedra, Melosira, Microcystis, Scenedesmus, Pediastrum, Peridinium* and *Euglena*), which occurred rather consistently throughout the survey, is shown in Figure 4. These genera indicate a periodicity quite comparable to that of the groups to which each belongs (Figure 3). The periodicity and abundance of other genera will be discussed later under the proper class of algae.

It is not known what effect the extremely dry season of 1930 had upon the abundance of plankton algae. The water in Buckeye Lake was lower than any previously known record.

Chlorophyceae.—The two most abundant genera of this class are *Scenedesmus* and *Pediastrum* (Figure 4). The former is represented by seven species and the latter by five species. Next in abundance is *Cosmarium*, occurring throughout the season in gradually increasing quantities until the end of the survey. *Tetraedron*, together with *Cosmarium*, is at variance with the Chlorophyceae considered as a whole. The remaining genera (Table II) of the Chlorophyceae occurred in too small quantities to warrant individual consideration.

The Chlorophyceae is the dominant group for Buckeye Lake for the whole season (Figure 3; Table I). Occasional cycles of *Peridinium* and *Euglena* are very abundant during certain periods (see below) and at these times the green algae seem scarce by comparison. The dominance of the Chlorophyceae in Buckeye Lake is in striking contrast to conditions in Lake Erie, where the diatoms are the evidently preponderant

TABLE I

CLASSES OF PLANKTON ALGAE IN BUCKEYE LAKE. AVERAGE NUMBER OF ORGANISMS, IN THOUSANDS PER LITER OF WATER. DURING EACH OF THE TWO-WEEKS PERIODS

	June 25–30	July 1–15	July 16–31	August 1–15	August 16–31	September 1–10
Chlorophyceae.......	168	129	120	133	87	162
Diatomeae..........	114	110	92	81	32	31
Myxophyceae........	18	48	62	62	65	60
Dinophyceae........ Euglenophyceae..... Chrysophyceae......	208	146	123	196	46	45

TABLE II

CHLOROPHYCEAE. AVERAGE NUMBER OF ORGANISMS, IN THOUSANDS PER LITER, OF GENERA OF CHLOROPHYCEAE, DURING EACH OF THE TWO-WEEKS PERIODS

	June 25–30	July 1–15	July 16–31	August 1–15	August 16–31	September 1–10
Scenedesmus.........	105.0	80.0	68.0	62.0	26.0	46.0
Pediastrum..........	34.0	17.0	16.0	16.0	8.0	18.0
Cosmarium..........	10.0	10.0	15.0	26.0	33.0	66.0
Tetraedron..........	8.0	9.0	10.0	14.0	14.0	22.0
Crucigenia...........	4.0	2.0	4.0	3.0	2.0	4.0
Closterium..........	2.0	3.0	2.0	1.0	0.3	0.0
Oocystis.............	1.0	3.0	4.0	3.0	0.3	5.0
Coelastrum..........	2.0	0.6	1.0	1.0	0.3	1.0
Sphaerocystis........	1.0	0.2	0.03	0.2	0.0	0.0
Staurastrum.........	3.0	1.0	2.0	2.0	0.3	1.0
Pandorina...........	0.5	2.0	1.5	2.0	0.0	0.0
Kirchneriella........	0.0	0.3	0.4	0.2	0.3	0.0
Euastrum............	0.0	0.8	0.3	0.01	0.0	0.0
Eudorina............	0.0	0.0	0.1	3.0	0.3	1.0
Dictyosphaerium......	0.0	0.05	0.0	1.0	0.0	0.0

group. In addition the maximum abundance of this group is not reached in Lake Erie until September. The relative rapidity with which the water of Buckeye Lake becomes warm in the spring is perhaps an important factor in the Chlorophycean maximum in June in such a relatively small lake.

Eddy (1927) found in a small lake in Illinois a maximum of Pediastrum in July, with a marked rise in June over May and a marked

decline in August. A second smaller maximum was noted in October. This July maximum in Illinois is, however, less than one half the phytoplankton productivity in Buckeye Lake for the same period. Muenscher (1929) reports a maximum of 500,000 organisms (nannoplankton) per liter in Lake Champlain in early August. A representative station from Lake Erie might show a maximum of 400,000 organisms per liter in August, with a count of 35,000 in September. The maximum production of Chlorophyceae at any one time for Buckeye Lake occurred in August with a count of 272,000 per liter. This should not be confused with the average counts for the two-weeks periods, mentioned above.

Diatomeae.—Ranking second to the Chlorophyceae, the diatoms occur rather regularly throughout the season but with relatively few species in abundance (Figure 3; Table I). The enormous "waves" of

TABLE III

DIATOMEAE. AVERAGE NUMBER OF ORGANISMS, IN THOUSANDS PER LITER, OF THE GENERA OF DIATOMEAE, DURING EACH OF THE TWO-WEEKS PERIODS

	June 25–30	July 1–15	July 16–31	August 1–15	August 16–31	September 1–10
Synedra	75.0	81.0	72.0	54.0	20.0	21.0
Melosira	29.0	14.0	11.0	9.0	5.0	6.0
Navicula	7.0	7.0	3.0	3.0	5.0	2.0
Surirella	2.0	1.5	0.4	0.5	1.0	0.0
Gyrosigma	1.0	5.0	4.0	7.0	1.0	1.0
Asterionella	0.5	0.5	0.0	0.0	0.0	0.0
Tabellaria	0.0	0.0	2.0	0.0	0.0	0.0
Amphora	0.0	0.1	0.04	0.0	0.0	0.0
Nitzschia	0.0	0.0	0.5	0.0	0.0	0.0
Cocconeis	0.0	0.0	0.5	0.0	0.0	0.0

Stephanodiscus, Asterionella, Tabellaria and *Fragilaria*, so characteristic of Lake Erie, were missing in the survey of Buckeye Lake. *Stephanodiscus* was not observed at all and the other genera occurred only sparingly in June and July. The dominant diatom throughout the season is *Synedra,* followed not closely by *Melosira* and *Navicula.* These genera are most abundant at the beginning of the season and apparently least abundant in late August and early September. Some other data for previous years indicate a rise in numbers for a short time during late September. *Surirella,* a diatom found perhaps more frequently in water with a higher organic content, follows the general seasonal distribution of the class as a whole. *Gyrosigma* is present throughout the season, though never abundant and is more common during early August. *Cymbella, Cocconeis* and *Nitzschia* were rarely observed. (Figure 4; Table III).

The autumn maximum of productivity of diatoms reached in Lake Erie is notably absent in Buckeye Lake. From a representative Lake Erie habitat there may be 300,000 organisms per liter in September and nearly 600,000 per liter in October, corresponding to only 31,000 in

September (no data for October) in Buckeye Lake. The month of August furnishes an interesting comparison (New York data from Muenscher, 1929); Buckeye Lake 159,000; Lake Erie 328,000; Lake Champlain 70,000; Upper Saranac Lake 40,000; Lower Saranac Lake 60,000; Middle Saranac Lake 50,000; Lake Placid (on July 10, 10,000 organisms per liter). Maximum numbers are considered only.

TABLE IV

MYXOPHYCEAE. AVERAGE NUMBER OF ORGANISMS, IN THOUSANDS PER LITER, OF THE GENERA OF MYXOPHYCEAE, DURING EACH OF THE TWO-WEEKS PERIODS

	June 25–30	July 1–15	July 16–31	August 1–15	August 16–31	September 1–10
Microcystis...........	9.0	28.0	52.0	58.0	60.0	53.0
Anabaena..............	3.0	2.0	2.0	2.0	1.0	1.0
Lyngbya..............	2.0	12.0	3.0	3.0	3.0	3.0
Coelosphaerium.......	0.5	2.0	4.0	0.3	0.0	0.0
Aphanizomenon.......	1.0	3.0	0.6	0.3	0.0	0.0
Merismopedia.........	0.0	0.1	1.0	2.0	2.0	4.0
Gomphosphaeria.......	2.0	0.0	0.1	0.0	0.0	0.0
Oscillatoria..........	0.0	0.0	0.0	0.0	0.1	0.0

TABLE V

DINOPHYCEAE, EUGLENOPHYCEAE, CHRYSOPHYCEAE. AVERAGE NUMBER OF ORGANISMS, IN THOUSANDS PER LITER, OF THE GENERA OF DINOPHYCEAE, EUGLENOPHYCEAE AND CHRYSOPHYCEAE, DURING EACH OF THE TWO-WEEKS PERIODS

	June 25–30	July 1–15	July 16–31	August 1–15	August 16–31	September 1–10
Peridinium...........	129.0	80.0	70.0	92.0	28.0	27.0
Euglena..............	58.0	55.0	38.0	77.0	16.0	19.0
Ceratium.............	14.0	7.0	6.0	15.0	1.0	0.0
Phacus...............	5.0	3.0	2.0	3.0	2.0	0.0
Dinobryon............	0.5	0.3	0.04	0.0	0.0	0.0
Synura...............	0.0	0.0	1.0	0.0	0.0	0.0

Myxophyceae.—It has been established in numerous collections that the blue green algae are decidedly summer and autumn forms. In the Buckeye Lake survey there is a steady rise in abundance from a low minimum in June to a maximum in late August and early September. In Lake Erie the Myxophycean maximum occurs in September (1938). When one considers the temperature of the water, however, it might be just as well to consider the blue greens "warm water" forms. Their absence in spring and early summer seems to be accounted for pretty largely on the basis of low temperature of water.

In the Buckeye Lake survey *Microcystis* is the only member of the plankton consistently present (Figure 4; Table IV). *Anabaena*, though

not very abundant at any time is present in largest numbers in early summer. The very shallow water along shore in 1930, particularly in protected places, became warm much earlier in the year than is usually the case. *Lyngbya* occurs most abundantly in early July. Both *Coelosphaerium* and *Aphanizomenon* are absent in late August and early September. For other genera see Table IV.

TABLE VI

Groups of Zooplankton in Buckeye Lake. Average Number of Organisms, in Thousands per Cubic Meter, in Each of the Two-weeks Periods

	July 1–15	July 16–31	August 1–15	August 16–31	September 1–10
Copepoda....................	34.0	108.0	88.0	53.0	93.0
Cladocera....................	11.0	16.0	7.0	15.0	7.0
Rotifera.....................	52.0	316.0	342.0	59.0	20.0

TABLE VII

Zooplankton Organisms in Buckeye Lake. Average Numbers of Organisms, in Thousands per Cubic Meter, of the Genera of Copepoda, Cladocera and Rotifera for Each of the Two-weeks Periods

	July 1–15	July 16–31	August 1–15	August 16–31	September 1–10
Copepoda					
Cyclops..................	13.0	61.0	58.0	39.0	61.0
Nauplii..................	21.0	45.0	30.0	14.0	32.0
Cladocera					
Daphnia..................	0.5	0.25	0.0	0.0	0.25
Pseudosida..............	5.0	13.0	4.0	14.0	6.0
Ceriodaphnia............	0.0	0.5	0.0	0.0	0.0
Immature Cladocera.......	6.0	2.0	2.0	2.0	0.25
Rotifera					
Asplanchna..............	0.0	0.0	9.0	2.0	2.0
Polyarthra..............	0.0	0.5	6.0	2.0	1.0
Brachionus..............	51.0	312.0	324.0	51.0	13.0
Rattulus................	0.25	4.0	4.0	6.0	4.0

Muenscher (1929) reports a maximum of 500,000 organisms per liter during early August in Lake Champlain and 400,000 in Lake Placid. In Lake Erie a maximum for the same period may be 500,000 per liter, while in Buckeye Lake the count runs only as high as 154,000 for the same month.

Dinophyceae.—*Peridinium* and *Ceratium* are unusually well represented in this survey (Figure 4; Table V). Their curve of distribution indicates a first maximum in June with a second in early August. The autumn maximum, characteristic of Lake Erie, is absent. The decline in late August and early September is very marked.

Peridinium occurs at times in tremendous quantities, the largest count being 672,000 on August 1. On the same day the count for *Ceratium* was 14,000 organisms per liter.

Euglenophyceae.—Euglena is the dominant genus, reaching a maximum in early August with a lesser maximum in June and early July (Figure 4). *Phacus* occurs rather regularly, though in much smaller numbers throughout the season.

Chrysophyceae.—Dinobryon and *Synura* are the only representatives of this class, the former occurring throughout June and July, the latter in late July only. They are perhaps not an important part of the phytoplankton.

If these last three classes of phytoplankton are considered as a unit, we get the high maximum of productivity in June, declining rapidly till the end of the survey in September (Figure 3; Table I; Table V).

DIURNAL CHANGES IN THE LAKE

Small bodies of water, shallow streams and fish ponds have been shown to exhibit marked changes in their chemistry during the 24 hours, while it has long been known that certain plankters perform daily, vertical migrations from one region of the lake to the other. At the time that Buckeye Lake was investigated little was known about the diurnal changes in a good sized lake and especially of the factors which caused the changes and differences in distribution of various plankton organisms. Even today, the subject is still more or less shrouded in mystery and no complete explanation has been given to explain many of the very complex migrations exhibited by some organisms.

On August 12–13, a 24-hour series of surface samples were taken every hour from a point about 100 meters off the laboratory. Zooplankton, phytoplankton, temperature, dissolved gases, pH and alkalinity were investigated. The chemical determinations were made immediately after the collection of the water. The results of chemical determinations and migrations of certain zooplankters are shown in Figure 5.

The following weather report for Columbus, kindly submitted from the Weather Bureau Office by Mr. W. H. Alexander, indicates that the afternoon of August 12 was quite similar to the forenoon of August 13, with the possible exception of the amount of sunshine.

"August 12, 1930, was a clear day with 100% of possible sunshine; the temperature ranged from 54 (the minimum) to 78 (the maximum) degrees Fahrenheit, averaging 66, or 8 degrees below normal; the wind was from the north and northwest with an average hourly velocity of 5.9 miles per hour, the highest velocity for the day being 14 miles.

"August 13, 1930, was also a clear day but with only 88% of the possible sunshine; it began clouding in the late afternoon and evening; the temperatures ranged from a minimum of 48 to a maximum of 85, giving an average of 72 or 2 degrees under the normal for the day; the winds were rather variable though the prevailing winds were from the northwest and the average velocity was 5.4 miles per hour with a maximum for the day of 14 miles from the south."
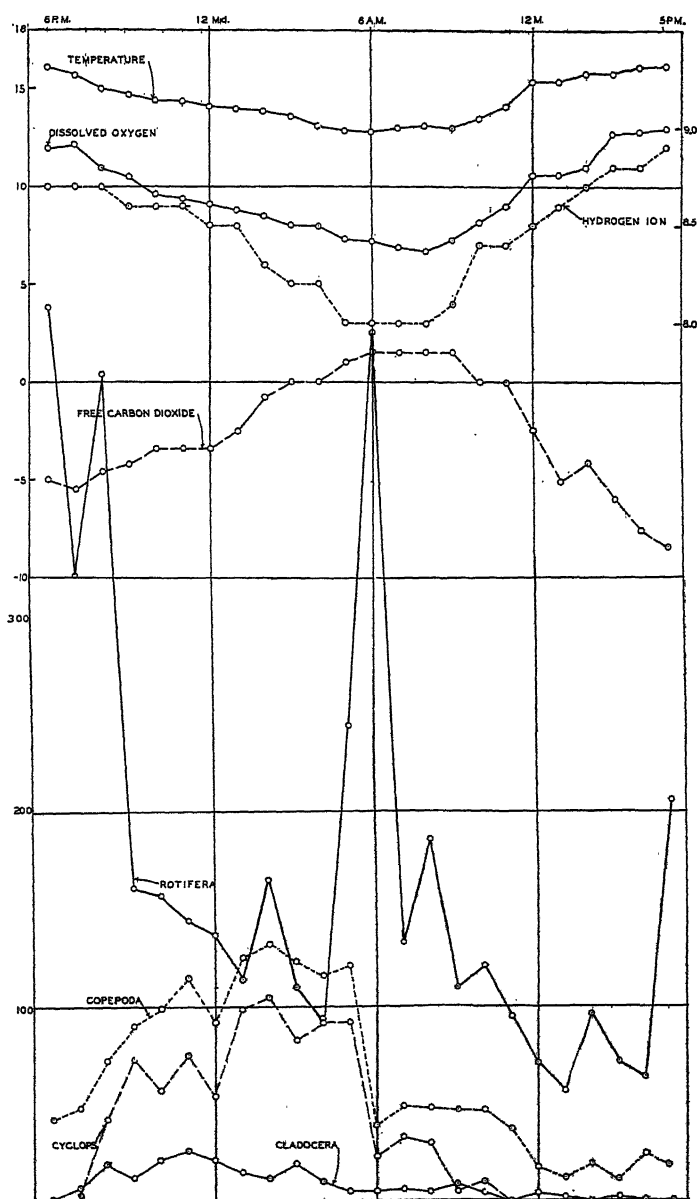
Fig. 5.   Diurnal changes in physical and chemical factors and in zooplankton at the surface on August 12–13, 1930.   Temperature is shown in degrees Centigrade, chemical factors in parts per million, plankton in organisms per liter; time is eastern standard time.

Physical and Chemical Changes.—The days selected for the observations thus turned out to be ideally suited for such an investigation. Water temperature was observed to lag behind air temperature during the 24 hours. The variation in water temperature amounted to only 3.4° C. while that of the air was 13.9° C. at the laboratory, clearly illustrating the difference in specific heat of the two mediums. The activity of the green plants in the water caused marked fluctuations in dissolved oxygen, free carbon dioxide and pH. Dissolved oxygen varied between 6.7 p.p.m. and 13.0 p.p.m., the lowest figure having been reached at 8 a. m., before the sun had been up long enough to make its presence felt in photosynthesis. The percentage of saturation showed even greater fluctuations and varied between 77% and 159%. This variation was due to the fact that the period of least oxygen occurred at a time when the water was able to hold more dissolved gas due to its lower temperature. Methyl orange alkalinity, as would be expected, remained at a practically constant level during the entire time. Free carbon dioxide, however, showed rather remarkable changes from hour to hour as the activity of the green plants varied with the amount of sunlight. By the first of August and for some time before, free carbon dioxide had been exhausted at the surface and a decided deficiency was noted at most times. During the 24 hour series, carbon dioxide varied from a deficiency of 5.0 p.p.m. at the start to actual free carbon dioxide between four and ten a. m. By 5 p. m. that afternoon a deficiency of 8.4 p.p.m. had been built up due to photosynthesis of the green plants. The pH varied inversely with the free carbon dioxide and ranged between 8.0 and 8.9.

The Zooplankton.—At the bottom of Figure 5 is shown the diurnal distribution of the major groups of zooplankton. The only copepod present was *Cyclops viridis americanus* and this species is represented separately as being the principal migrant. The graph marked "Copepoda" includes the immature stages as well as adults of this species. Both of these curves show higher numbers of individuals at the surface during the hours of darkness. In very bright light the adult copepods deserted the surface completely and were absent from nine a. m. until late afternoon. The nauplii, on the other hand, although not nearly as abundant at the surface during the hours of intense sunlight, were nevertheless present in fair numbers. Light intensity seems therefore, to be an important factor in the migration of adult copepods in Buckeye Lake.

The rotifers showed a distinctly different type of migration. The time of maximum numbers at the surface will be seen in Figure 5 to coincide with the time of sunrise and sunset, or at a time of diffuse light. Sume crustaceae have also been shown to prefer diffuse light (Juday, 1902), but in Winona Lake, where these observations were made, there was no morning increase observed to correspond with the evening maximum. The rotifers in Winona Lake were found by Juday to show no indication of a diurnal migration. This is perhaps due to the different genera there (*Mastigocera, Polyarthra, Asplanchna, Keratella, Triarthra* and *Notholca*). In Buckeye Lake by far the greatest number of rotifers were of the genus *Brachionus*.

The Cladocera, which never reached any great number in the open water of the lake, followed in general the migrations of the copepods,

being at the surface during the night and deserting it with the appearance of the sun during the daytime.

The Phytoplankton.—It is difficult for one to appreciate the significance of the "peaks" of the curves in the diurnal periodicity of the phytoplankton, due to the fact that collections were made but once each hour on this particular occasion. Factors other than those incident to the mere changes from hour to hour are not known. The Chlorophyceae reached a corresponding peak at 3:00 p. m., 5:00 p. m., 7:00 p. m. and 2:00 a. m., being consistently lowest from 4:00 a. m. until noon. The Myxophyceae and Diatomeae were fairly regular throughout the 24 hours. The three other classes were most abundant immediately after noon. The quantity of Chlorophyceae and Dinophyceae-Euglenophyceae-Chrysophyceae was considerably lower, on the average, at noon of August 13, than at 1:00 p. m. the preceding day. The available sunshine decreased also. Very little variation was noted in the diatoms and blue-greens.

PRODUCTIVITY

Buckeye Lake is a eutrophic lake which exhibits extremely high productivity during the summer months. Particulate organic matter, shown for station 1 in Figure 2, ranged from 6600 mgs/m^3 to 18,100 mgs/m^3 at this station. At station 2 the surface waters ranged from 5,900 to 13,600 mgs/m^3. 18,100 mgs/m^3 was the maximum amount of organic matter observed at any time in the lake in 1930. That this figure represents a truly enormous amount, may be appreciated when it is recalled that Birge and Juday (1934) in a study of 529 Wisconsin lakes found particulate organic matter to range from 230 to 12,000 mgs/m^3 with a mean of only 1,360. The time of maximum organic matter in Buckeye Lake occurred at the same time as the maximum zoo- and phytoplankton abundance and in general the summer variation followed very closely the total counts for these organisms. During the height of activity of the lake in early August, the water was so densely populated with algae that it truthfully may be said to have appeared like pea soup. This overpopulation is reflected in the high organic matter and in the extremely low transparency of the water at this time.

In its vertical distribution, particulate organic matter at station 2, showed a greater amount at the surface than at 5 meters in three instances and more at the bottom in two; at other times the amount was about the same at both depths. The larger amount at the surface may be explained by the greater amount of plankton at this level, while stirring up of bottom debris may account for the larger amount at the bottom on the two occasions. The vertical distribution of organic matter has been shown to be very variable in different lakes.

The horizontal distribution of organic matter was very irregular. In general, the stations at the western end and in the sanctuaries showed more organic matter and the least amount was observed at stations 25 and 27 (1,700 and 2,300 mgs/m^3 respectively). This is reflected in the greater transparency found at these stations. The organic matter was also low in the bog hole on Cranberry Island (2,100 mgs/m^3). Station 1 in Buckeye Lake varied between 168,300 and

212,800 mgs/m³ of dry residue while station 2 showed a maximum of 228,400 mgs/m³ at 5.5 meters on August 18. The surface waters of station 2 varied between 177,000 and 201,700 mgs/m³ of dry residue. Lake Wingra, a small lake of comparable depth in Wisconsin, averaged 271,000 mgs/m³ for the year (Tressler and Domogalla, 1931). Other factors besides the plankton enter into these results. These are the debris which is stirred up from the bottom by high winds and which accounts for the higher figures obtained at 5 meters at station 2 and drainage from the land, which was not a factor of importance during the first part of the summer.

The combined results of particulate organic matter and dry residues show very clearly the extreme eutrophy of Buckeye Lake during the summer months.

BOTTOM ORGANISMS

Procedure.—An Eckman dredge, 20 cm. by 20 cm. was used to collect samples of the bottom. The date, approximate depth and position of the station were recorded at the time the sample was taken and in most cases the nature of the bottom (mud, sand or gravel) was recorded. The samples were placed in four gallon pails and covered with lake water. Within an hour of the time the samples were taken they were washed through a net made of silk bolting cloth, No. 36, which had 13 strands to the centimeter. The sample, washed free of mud, was then transferred to a quart or two-quart jar, marked and left at the laboratory for removal and identification of the organisms. Samples which were not immediately examined were preserved by the addition of formalin. It was found that the counts of *Tanypus* and *Chironomus* larvae and *Limnodrilus* were made about as well from formalin as from fresh material. Such soft bodied forms as the Hydracarinae and *Chaoborus* were, however, largely lost in formalin material.

The laboratory procedure was as follows: About 25 cc. of the sample, consisting of the debris and the organisms, which had been held back by the silk net were placed in a flat glass dish and a little fresh lake water poured over it. This was closely inspected, frequently stirred and worked over and the organisms picked out with forceps and either identified immediately and tabulated or put aside in vials, marked and later identified. No attempt was made to isolate and identify the plankton crustaceans, such as ostracods and cladocerans, some of which were often found in the samples. *Hyalella*, however, was counted as it is a much larger form. Only a few nematodes were taken from the fresh samples, although they undoubtedly occur in great numbers in the mud of the lake bottom. From the size of those found now and then in the samples, it is likely that the great majority went through the meshes of the net. It is also true that these forms are almost at the edge of visibility with the naked eye and for this reason most of them would be missed, particularly in the preserved material. In many samples Bryozoan statoblasts were observed in large numbers. No attempt, however, was made to keep a record of them as they float in the lake water at the season the samples were taken and many of them

no doubt came from the water used in washing the sample and not from the sample itself.

The Data.—A tabular summary of the organisms collected in the 246 samples has been made and together with a map of the lake showing the exact location of each station, is on file at the office of the Division

TABLE VIII

SUMMARY OF BOTTOM ORGANISMS. THE TOTAL NUMBER OF ORGANISMS COLLECTED
AT VARIOUS STATIONS FOR EACH MONTH IS SHOWN. THE GRAND
TOTAL FOR THE SURVEY AND THE PERCENTAGE OF THE TOTAL
FOR THE MORE IMPORTANT ORGANISMS ARE ALSO GIVEN

	July	August	September	Total	Per Cent Total
Diptera					
Palpomyia.................	15	52	13	80	0.77
Corethra..................	45	266	133	444	4.26
Tanypus..................	1623	2444	959	5026	48.29
Chironomus..............	928	1111	516	2555	24.74
Coleoptera					
Donacia..................	3	0	0	3	.....
Cybister..................	0	0	1	1	.....
Hemiptera					
Corixa....................	0	1	9	10	.....
Ephemerida					
Hexagenia................	0	0	2	2	.....
Caenis...................	1	0	4	5	.....
Odonata					
Didymops................	0	0	3	3	.....
Nehallenia...............	2	0	9	11	.....
Trichoptera					
Leptocerus...............	1	0	0	1	.....
Hydroptilidae............	13	3	7	23	.....
Neuroptera					
Sielis....................	87	53	16	156	1.5
Crustacea					
Hyalella..................	71	114	137	332	3.09
Arachnida					
Hydracerina..............	3	60	55	118	1.13
Mollusca					
Musculium...............	63	21	1	83	0.81
Oligochaeta					
Nais.....................	0	0	5	5	.....
Branchiura sowerbyi.......	2	9	4	15	.....
Limnodrilus..............	743	233	511	1487	14.89
Hirudinea					
Herpobdella..............	2	2	1	5	.....
Glossophionidae..........	1	0	0	1	.....
Nematoda...................	0	0	16	16	.....

of Conservation at Columbus. In Table VIII is given a list of the organisms collected and identified with the total numbers secured in each month, the total collected during the summer and the per cent of the total of some of the more abundant forms. The samples were all taken at depths of between 0.2 and 3.7 meters so that depth plays an insignificant part in the distribution of these organisms in Buckeye Lake. In

other deeper lakes a regular zonation correlated with depth has been observed. This was shown very nicely in a recent paper by Townes (1938) on the bottom organisms in Chautauqua Lake, where small chironomids were found in shallower sandy parts, while in the deeper water, where muck bottom prevailed, *Limnodrilus, Chaoborus, Tanypus* and larger species of *Chironomus* were found.

An inspection of the summary in Table VIII shows that almost all the forms belong either to the chironomid larvae or to the tubificid worms. Of the total of 10,408 organisms recorded, there are 2,575 or about 25 per cent *Chironomus*, 5,026 or nearly 50 per cent *Tanypus*, 444 or over 4 per cent *Chaoborus* and 1,487 or 14 per cent *Limnodrilus* or closely related genera of tubificids. Thus over 75 per cent by number of the forms are chironomids and less than 10 per cent of the forms come from groups other than chironomids and tubificids. With the abundance of chironomids it may be noted that there are practically no mayfly larvae. Buckeye can certainly be classed as a chironomid lake.

Certain of the facts noted can best be discussed by taking up the major groups of organisms collected individually.

Diptera.—As the chironomids formed by far the most abundant organisms from the bottom samples, a representative lot were weighed, live, dry and ashed. The following data were obtained:

Name	No. of Individuals	Wt. of Empty Dish	Live Wt. With Dish	Dry Wt. With Dish	Ash Wt. With Dish
Chironomus.....	84	17.4063	19.4285	17.5565	17.4371
Tanypus........	139	19.1496	19.4385	19.1795	19.1536

If the individuals taken represent a fair sample of the total collected, then the organic matter of the total *Chironomus* larvae collected (2,555) would amount to 3.630 grams and that of the total *Tanypus* collected (5,026) would be 0.936 grams. It is obvious that while *Tanypus* is more abundant, the *Chironomus* larvae represent a much larger amount of food material by weight. Records were not kept of the variation in size of *Chironomus* and *Tanypus* from month to month as it seemed that the investigators were dealing with several different species, the identification of which was too difficult to make a study of growth feasible. It may be stated, however, that large numbers of extremely small *Chironomus* and *Tanypus* were found in the September counts. These must have been recently hatched individuals. This would agree with the observations on the swarming of adults around the lake in late August and the opening days of September.

It seems likely that *Chaoborus* occurs relatively more abundantly than recorded. Many individuals were doubtless lost in the formalin samples owing to the extremely fragile nature of this larva. This form certainly cannot, however, be of the importance of the other two genera as food for young fishes in Buckeye Lake.

Neuroptera.—156 *Sialis*, 1.5 per cent of the total organisms found were recorded. On the basis of the amount of organic matter in four individuals, which was determined, the total amount of organic matter

in the 156 *Sialis* collected was estimated to be 0.876 grams, a figure comparable with that obtained for the total *Tanypus* catch. While the numbers were small, it would seem that this form was relatively less abundant in September than in July, which probably indicates that the adults were emerging at this time of year.

Trichoptera, Odonata, Ephemerida, Hemiptera, Coleoptera.—These forms of insect life seem to occur only sporadically. The bottom of the lake being mostly mud, it seems likely that many micro-mayflies may have been overlooked in the samples. It is also probable that many more of the above orders would be found if the animal life on and around submerged water plants were studied. In any estimate of the total food material available to young fishes in a lake such as Buckeye, it would seem that that part of the fauna living on submerged vegetation should be taken into consideration. This very abundant animal life is accounted for neither in bottom nor plankton studies. Chandler (1937) has shown recently that a large part of the plankton of a lake is lost, when the water leaves the lake by way of stream, by being caught up by the detritus on the outside of submerged vegetation. The same thing very probably is true of plankton in weedy areas of a lake and very likely is an important factor in accounting for the increased transparency of the water in the weeded areas at the eastern end of the lake.

Arachnida and *Crustacea.*—Water mites were found rather abundantly in certain samples. The distribution of *Hyalella* was found to be sporadic, 112 of the 322 recorded specimens coming from one sample. This form is probably better considered with the plankton than with the bottom fauna.

Annelida.—Only five leeches were found. Small tubificid worms occurred widely distributed and abundant at many stations. A number of these were examined and from their external anatomy, setae, etc., they were placed in the genus *Limnodrilus*. Some of these may, perhaps have been *Tubifex*, as a careful examination of the individual specimen is necessary to separate these genera. *Nais* was likely present much more often than the counts indicate but it lies on the border of visibility with the naked eye and would often be overlooked.

From the zoologist's viewpoint, by far the most interesting item turned up during the summer's work was the finding of fifteen specimens of the gilled annelid, *Branchiura sowerbyi*. A more detailed description of this interesting worm is given in another paper (Spencer, 1932). This is the first record of this rather rare species from the western continent. It has formerly been recorded from the Royal Botanical Society's gardens, Regents Park, London, the Botanical Gardens of Hamburg and of Göttingen, from several canals and ponds in France, from India and Japan. The worm is a tubificid with a series of some sixty pairs of gill-like respiratory processes, one pair to a segment on the posterior third of the worm. The gills extend at right angles to the long body axis, in the mid-dorsal and mid-ventral lines. They diminish in length anteriorly becoming mere knobs and finally disappearing entirely. Several of these worms were kept alive and under observation in the laboratory for several days and a careful study was made of their

behavior, external anatomy and setae. *Branchiura sowerbyi* was taken at six different stations, which indicates that the worm is fairly well distributed in the central part of the lake. If it is an introduced species, it must have been established for several years to have gained its present distribution in the lake. Where it has been found in other regions it has not been taken in large numbers. Stephenson (1912) bases his description on seven specimens taken in India and Beddard's original paper (Beddard, 1892) is based on about the same number of individuals.

Nematoda, Gordiacea.—Nematodes are probably abundant but too small to be observed readily without the use of a microscope and are often washed through the net. Very few Gordiacea were found.

Mollusca, Bryozoa.—Half a dozen or so small specimens of snails, classified as *Physa, Planorbis* and *Limnaea* were taken but were not tabulated. A small bivalve occurred in some numbers. It was tentatively classified as *Musculum*, although this may not be correct. One bivalve about five centimeters long and unidentified was taken at station 185.

A bryozoan colony was found in the sample from station 167. As already stated many bryozoan statoblasts were seen but were not recorded.

SUMMARY

1. During the summer of 1930, from June 25, to September 10, an extensive study of Buckeye Lake was carried out under the auspices of the Division of Conservation of Ohio. Buckeye Lake is a long, narrow lake located about thirty miles east of Columbus, Ohio, which has a maximum depth of about seven meters and a mean depth of around two and one half meters.

2. The temperature reached an observed maximum of 29.0° C. at the surface. The transparency varied between 0.3 and 0.7 meters, low figures being due to the great abundance of plankton material and the shallowness of the lake. The color is low, about 25 on the platinum-cobalt scale.

3. Dissolved oxygen was present in abundance at all depths, except at five meters and below in the deep hole, due to the decomposition on the bottom. Free carbon dioxide was present later in the summer than in most lakes due to the decomposition of the bottom materials and to the lake's shallowness. Methyl orange alkalinity reached a maximum of 96.0 p.p.m., showing the waters to be hard. The pH varied between 7.3 and 8.9 in the limnetic regions. Chlorides were found in minute traces only. Soluble phosphorus was low during the summer; dissolved silica was not very abundant. Nitrates were fairly low due to their consumption by algae. Free ammonia declined to a low point by the end of the summer.

4. Rotifers were the most abundant zooplankton organisms.

5. The Cladocera were never present in great numbers in the limnetic region.

6. Of the copepods, *Cyclops viridis americanus* was the most abundant species.

7. The lake reached a maximum of activity during the first week in August. At this time there was more oxygen, more plankton and the temperature was the highest; organic matter was also at a maximum.

8. The zooplankton organisms were found to be unevenly distributed over the limnetic area of the lake and occurred in patches or swarms here and there.

9. The Chlorophyceae was the dominant group for the lake during the period covered by the survey and reached a peak in June and another in September. Most abundant genera were *Scenedesmus* and *Pediastrum*.

10. The Diatomeae varied in abundance from a maximum in June, gradually decreasing to a minimum in early September. The dominant diatom was *Synedra*, followed not closely by *Melosira* and *Navicula*.

11. The Myxophyceae varied from a low minimum in June, gradually increasing to a maximum in late August and early September. The most abundant blue-green alga was *Microcystis*.

12. The Dinophyceae, represented by *Peridinium* and *Ceratium*, reached a first maximum in June with a second in late August. The decline in early September was very marked.

13. The Euglenophyceae, as shown by the presence of *Euglena*, reached a maximum in early August preceded by a lesser maximum in late June and early July. *Phacus*, though present in small numbers throughout the survey, showed no definite periodicity.

14. The Chrysophyceae was an unimportant group of the algal plankton of the lake. *Dinobryon* occurred in June and July and *Synura* in late July only.

15. Studies of the diurnal changes over a 24 hour period showed considerable fluctuation both in chemical determinations and in migrations of plankton.

16. The particulate organic matter was extremely high (maximum of 18,000 mgs/m^3. Dry residue reached a maximum of 228,400 mgs/m^3. Buckeye Lake is therefore an extremely productive lake of the eutrophic type.

17. The bottom of Buckeye Lake was sampled for bottom organisms; 246 samples were taken with an Eckman dredge, 20 cm. by 20 cm.

18. The chironomid larvae formed over 75% by number of the bottom organisms recorded. *Limnodrilus* formed about 15%.

19. There was almost a complete absence of mayfly larvae.

20. *Branchiura sowerbyi*, a gilled tubificid worm, was found at six stations in the central part of the lake. 15 specimens were taken in the bottom samples. This is the first record of this form in the western hemisphere.

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LIMNOLOGICAL STUDIES OF WESTERN LAKE ERIE

I. PLANKTON AND CERTAIN PHYSICAL-CHEMICAL DATA OF THE BASS ISLANDS REGION, FROM SEPTEMBER, 1938, TO NOVEMBER, 1939

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INTRODUCTION

One phase of the fisheries research program now in effect at the Stone Laboratory is the year-round quantitative study of the basic fish foods in the region of the Bass Islands of Lake Erie, and of the ecological factors affecting the various components of this food. The present paper is the first of a series dealing with this subject and it is concerned primarily with year-round data derived from weekly plankton collections and certain physical · and chemical determinations in this vicinity. The region of the Bass Islands, like the rest of the shallow western end of Lake Erie, serves as the spawning and feeding grounds for many fish of commercial value. The specific area selected for study was chosen because of its accessibility from the Stone Laboratory and its suitability for winter work due to the fact that from late December to late March it possesses an ice-cover through which investigations can be conducted safely.

Often the bulk of a given species of fish caught during so-called good years belongs to a single year group, the members of which were hatched several years previously. Annual fluctuations in abundance of a species and the dominance of this species by a single year group, as revealed by analyses of commercial catches in this region, immediately suggest that environmental conditions antecedent to time of maturity of a fish may be of considerable significance. It is conceivable that

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an abundance of fertilized eggs may be produced during the spawning period of a species but due to unfavorable physical and chemical conditions of the water, or to the lack of proper planktonic food for the newly hatched young, few mature fish will be produced.   Since utilization of plankton by adult or immature fish depends upon its abundance and its availability, a plankton investigation becomes an essential part of this program.   Data in this paper are general in nature but nevertheless they furnish a basis for future work.

REGION STUDIED

Three natural divisions exist in Lake Erie: the deep eastern portion (that east of a line connecting the city of Erie and the tip of Long Point) with a maximum depth of 64 meters, the central area (that portion west of Long Point and the city of Erie to a line connecting Point Pelee and the city of Sandusky) with a maximum depth of 24.5 meters, and the shallow western end (the remaining portion of the lake) with a maximum depth of 16 meters (Fig. 1). General limnological surveys of these three divisions have been made; the report dealing with the eastern end has been published by Fish (1929), and a summary report of the investigations of the western end has been published by Wright and Tidd (1933). A report pertaining to the studies of the central area has not been published as yet. The present paper is concerned with only a portion of the western end of Lake Erie, that part in the immediate vicinity of the following islands: South Bass, Middle Bass, North Bass, Rattlesnake, and Green (Fig. 2). This region is referred to in this paper as the Bass Islands Region. Wright and Tidd (1933) studied the entire western end of the lake and divided it into several sections, one being designated as the "Island Section" which included approximately the eastern two thirds of the western end of the lake. The Bass Islands Region should not be confused with the much larger "Island Section"; however, except for size these two divisions are quite similar as will be shown later.

The present investigation was confined to an area, consisting of approximately 1000 acres and uniformly 9 to 10 meters deep, lying between the following islands: South Bass, Middle Bass, Rattlesnake, and Green (Fig. 2). Due to currents and wind action this shallow water is kept in continuous circulation throughout most of the year. During winter an ice-cover is formed in this region and extends various distances depending upon the severity of the winter. Some winters

result in an ice-cover forming over the entire western end of the lake, while others, like the winter of 1938–39, produce an ice-cover nearly limited to the Bass Islands Region. During this particular winter ice did not form until late December, 1938, and did not exceed two inches in thickness until late January, 1939. It later reached a maximum thickness of eight inches. The ice-cover remained until late March, but several times during this period it broke up and shifted away from the islands for a short time, later returning to produce a continuous ice-cover. Each time the ice broke up wind action produced violent churning of the water resulting in complete circulation and increased turbidity.
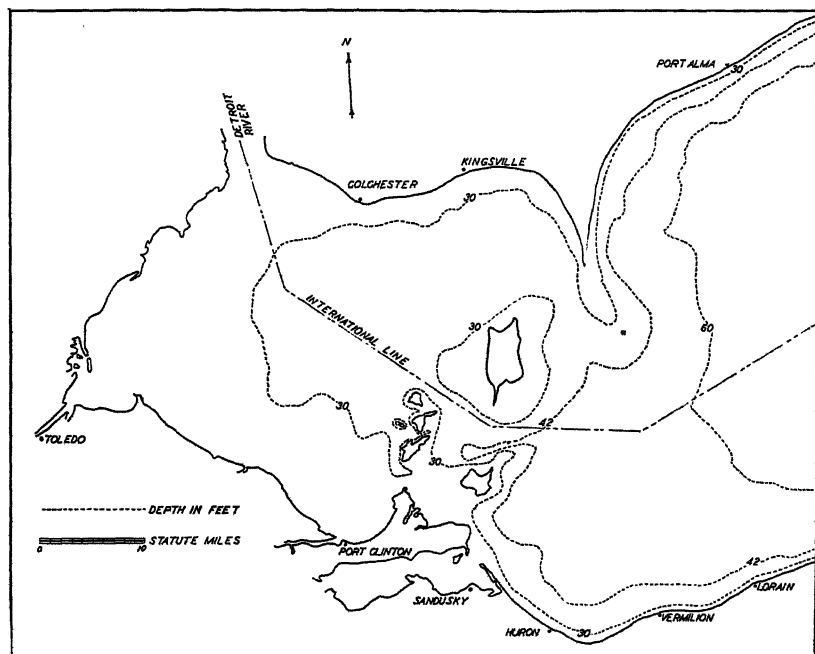
Fig. 1. Map showing the western part of Lake Erie. *Modified from the map of Lake Erie including the waterways between Lakes Ontario and Huron. Published by the U. S. Lake Survey Office June 2, 1939.*

Currents in this area, both surface and sub-surface, are known to exist, but no particular study was made of them. At times of high wind velocities large waves are formed which pound against the steep rocky shores, producing undertow currents of considerable magnitude. Also, these strong winds force the water between the islands setting up currents traveling in various directions. These and the undertow currents produce unpredictable disturbances which may be of considerable importance in respect to plankton distribution. During periods of ice-cover strong currents may be observed to flow in one direction for a few hours, then subside, and later a current will move in the opposite

direction.   Hook and line fishermen in this region claim that when the
currents are strongest, fishing through the ice is best, irrespective of the
direction of flow. This suggests that these currents may be an important
factor in the movements of fish in this region.
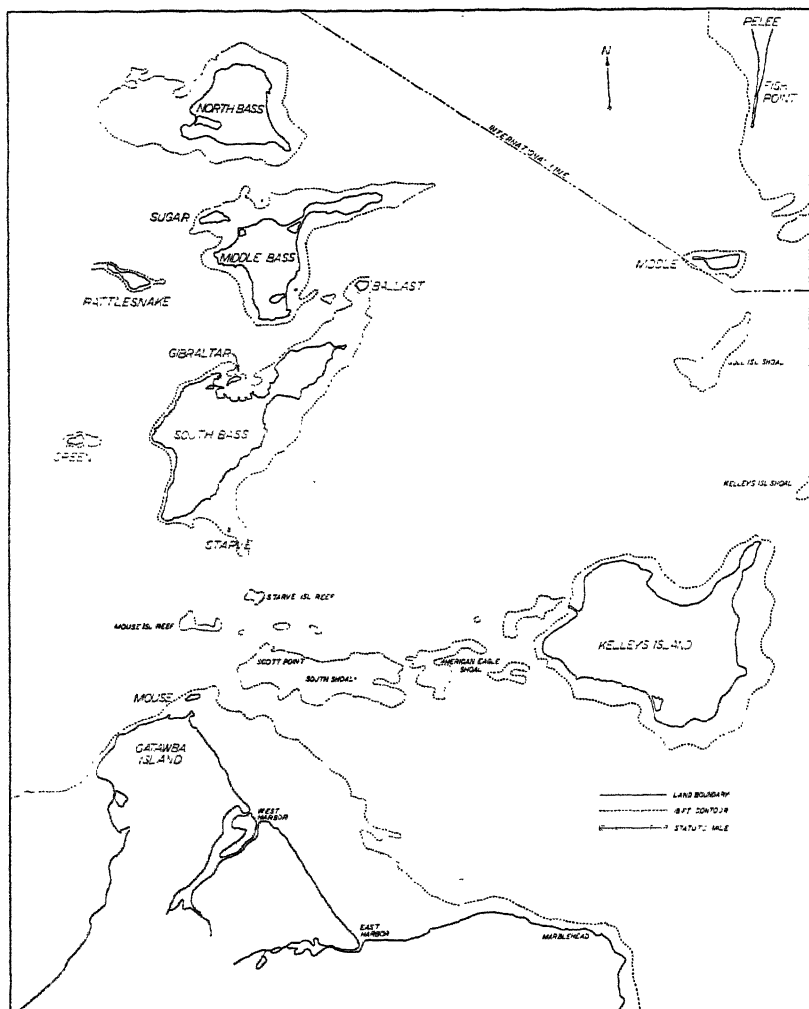
Fig. 2. Map showing the islands and shoals of Lake Erie in the vicinity of
Gibraltar Island, on which the Stone Laboratory is located. *Modified from the map
of the Islands in Lake Erie including Sandusky Bay, Ohio. Published by the U. S.
Lake Survey Office July 9, 1937.*

Bottom sediments in the area studied consist of clay, sand, fine
gravel, and organic detritus, appearing in various combinations. Some
of these sediments are very compact indicating that they are constantly

swept by currents, while others are soft and apparently free from the influence of currents. These sediments are being studied from the standpoint of organism content, and their mechanical and chemical nature, a report of which will appear at a later date.

METHODS AND EQUIPMENT

During periods of open water all collections were made from a scow (Fig. 5) which was towed to and from collecting stations by a motor boat. On the deck of this scow was mounted a davit equipped with a winch and meter-wheel. A 3-16 inch wire cable was threaded
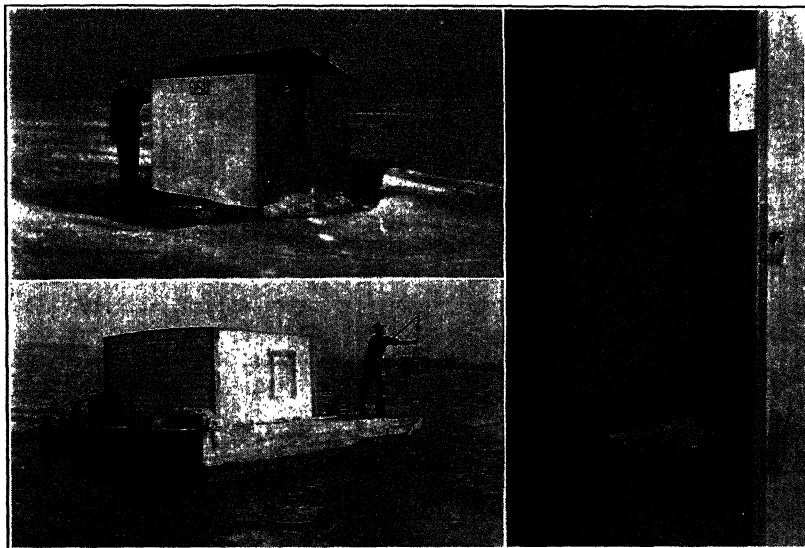
Fig. 3 (upper left).   Shanty from which all collections through the ice were made.
Fig. 4 (right).   Inside view of shanty showing arrangement of winch and meter-wheel.
Fig. 5 (lower left).   Scow from which all open water collections were made.

from the winch through the meter-wheel and was used to raise and lower all equipment. When work was done through an ice-cover the same equipment was mounted in an ice-shanty (Figs. 3 and 4) 8 ft. long, 5 ft. wide, and 6 ft. high.   In the floor of the shanty are two holes two feet square which make it possible for two persons to work simultaneously. A small stove installed in one corner keeps the shanty comfortably warm regardless of outside conditions.   On two occasions collections were made from this shanty when the air temperature was —5° F. without experiencing any discomfort.

All temperature determinations were made with a Negretti and Zambra reversing thermometer. Temperatures were taken at intervals of 1 meter from the surface to bottom, when surface temperatures varied

more than 2 degrees centigrade from those of the bottom; otherwise, determinations were made at the surface, 5 meters, 9 meters, and bottom. A continuous recording thermograph, recording air and surface water temperatures, was used to supplement field observations during the latter part of the investigation.

Turbidity was determined to the nearest 5 p.p.m. by means of the La Motte turbidity standards when turbidity did not exceed 100 p.p.m. When turbidity exceeded 100 p.p.m. a Jackson turbidimeter was employed.

Transparency was measured by means of a standard Secchi disc, suspended by a chain calibrated in centimeters. The disc was lowered until it disappeared, then raised until it appeared, and the average of the two readings was accepted as the transparency reading. All readings with this disc were made under shaded conditions. Readings through the ice were often made inside the shanty.

Light penetration was measured by means of a Weston photometer mounted in a water tight case, similar to the one described by Atkins, Clarke, etc. (1938). Readings were made of the intensity of total visible illumination in microamperes and milliamperes as recorded by a microammeter. The instrument was calibrated in foot candles and was found not to be sensitive to intensities less than 1.5 foot candles. Readings were made of direct sunlight in air and in water at the following depths: at intervals of 10 centimeters from surface to a depth of 1 meter, at intervals of 0.5 meter from 1 meter to 4 meters, and at intervals of 1 meter from 4 to 10 meters. Data were collected to show the intensity of total visible light at various depths as a percentage of surface light. When an ice-cover was present readings were made through a hole in the ice, either in the shanty or in the open.

Measurements of wind velocity at time of collections were made with a hand anemometer and stop watch. Velocity was expressed in miles per hour.

Water samples for all chemical analyses were collected with a modified Kemmerer water bottle. Hydrogen-ion concentration was determined by the La Motte colorimetric standards. Dissolved oxygen, free carbon dioxide, carbonates, and bicarbonates were determined by methods outlined in the Standard Methods of Water Analysis, 8th edition (1936).

Zooplankton was collected at intervals of 1 meter from surface to bottom by means of a 10 liter plankton trap, equipped with number 25 silk bolting cloth. Samples were preserved immediately with 4 per cent formalin and later were concentrated to 3 cubic centimeters with a pipette covered at the lower end with a double thickness of number 25 silk bolting cloth. The concentrate was placed in a 3 cubic centimeter counting chamber and all zooplankters were enumerated, and expressed in numbers per liter. At times of heavy pulses it was necessary to count only half of the sample and make the proper correction.

Phytoplankton collections were made at surface, at 5 meters, and at 9 meters, by collecting one liter of water with the water bottle. These samples were taken to the laboratory and centrifuged with a Foerst continuous flow centrifuge operating at 20,000 R. P. M. The concen-

trate was transferred from the centrifuge bowl to a vial and was preserved with 4 per cent formalin. Examination of these samples consisted of a qualitative and quantitive enumeration of phytoplankters with a Sedgewick-Rafter cell and a Whipple micrometer. In most cases the concentrate of each sample was diluted to 12.5 cubic centimeters; however, during periods of high turbidity it was necessary to dilute each sample to 25 cubic centimeters. The diluted sample was mixed thoroughly by shaking and then 1 cubic centimeter of it was transferred to the counting cell. All phytoplankters were counted in 10 cubic millimeters in each of two cubic centimeters of concentrate and this number was multiplied by the proper factor, usually 625, to convert to numbers per liter.

Unfortunately, many published phytoplankton data have lost their value through a failure of the investigator to state what units were used in counting various algae. In order that phytoplankton data of this investigation might be compared directly with that obtained by Wright and Tidd (1933) the same units have been adopted. The following have been considered as one unit: one cell of *Navicula, Stephanodiscus,* and *Synedra;* one colony of *Coelastrum, Coelosphaerium, Oöcystis,* and *Pediastrum;* 4 cells of *Scenedesmus;* 5 cells of *Dinobryon;* 8 cells of *Asterionella, Crucigenia, Diatoma,* and *Tabellaria;* 300 micra of *Melosira, Oscillatoria, Lyngbya, Anabaena,* and *Aphanizomenon;* and 100 micra of *Fragilaria.* Genera not mentioned above, when encountered, were assigned comparable units.

PHYSICAL DATA

TEMPERATURE

Temperature conditions of the water investigated are quite uniform from surface to bottom, due to shallowness and frequent agitation by wind action. Table I shows water temperatures at approximately weekly intervals from Sept. 2, 1938, to Oct. 26, 1939. It will be noted that on a given date temperature did not vary more than 2° C. from surface to bottom during this period, except on three occasions: May 9, May 23, and July 8, 1939. On these three dates thermal stratification was sufficient to form thermoclines. Temperature determinations at intervals of one meter, on May 9, showed that the top of the thermocline was at 5 meters with a temperature of 11.95° C. and the bottom at 8 meters with 9.91° C. No thermocline was detected during the following week, but on May 23 a thermocline reappeared. Temperatures on this date at intervals of one meter from 5 meters to bottom were as follows: 5 meters, 17.4° C.; 6 meters, 16.60° C.; 7 meters, 15.60° C.; 8 meters, 16.80° C.; 9 meters, 12.80° C.; and bottom, 12.60° C. This temperature series shows thermoclines between 6 and 7 meters, and 8 and 9 meters. At 8 meters the water temperature was 1.20° C. warmer than at 7 meters, which indicates that these conditions were temporary and probably due to currents. Again on July 8, a thermocline was found to exist between 5 and 7 meters. No doubt thermoclines existed on other dates than those mentioned, but it seems evident that thermocline formation is an irregular and temporary phenomenon, of little biological significance in this area.

TABLE I. Temperatures in Degrees Centigrade

Depth in Meters	Sept. 2 1938	Sept. 7	Sept. 16	Sept. 23	Sept. 28	Oct. 5	Oct. 12	Oct. 17	Oct. 28	Nov. 1	Nov. 5	Nov. 10	Nov. 17	Nov. 23	Nov. 29	Dec. 5	Dec. 15	Dec. 19
0	22.80	21.05	20.65	17.40	18.00	16.80	15.80	17.80	12.30	11.83	12.00	10.80	7.96	7.60	3.10	3.60	1.55	1.00
5	22.80	20.95	20.65	17.30	17.80	16.80	15.80	16.10	12.20	11.81	12.00	10.45	8.00	7.60	3.20	3.60	1.55	1.00
9	22.70	20.80	20.65	17.20	17.80	16.80	15.80	16.00	12.20	11.81	12.00	10.30	8.00	7.60	3.20	3.60	1.55	1.00

Depth in Meters	Jan. 10 1939	Jan. 23	Feb. 2	Feb. 11	Feb. 17	Feb. 25	Mar. 4	Mar. 10	Mar. 29	Apr. 5	Apr. 11	Apr. 18	Apr. 25	May 3	May 9	May 16	May 23	May 30
0	1.55	0.02	0.03	0.02	0.10	0.02	0.03	0.10	0.90	2.90	3.20	3.65	7.20	8.40	12.03	12.83	17.70	17.40
5		0.02	0.02	0.02	0.10	0.02	0.03	0.10	0.90	2.90	3.10	3.60	6.60	8.10	11.95	12.60	17.40	17.35
9		0.02	0.02	0.02	0.10	0.02	0.03	0.10	0.90	2.90	2.95	3.60	6.57	8.08	9.60	12.60	12.80	17.20

Depth in Meters	June 5 1939	June 14	June 22	June 29	July 8	July 22	Aug. 1	Aug. 11	Aug. 26	Aug. 31	Sept. 6	Sept. 12	Sept. 19	Sept. 25	Oct. 3	Oct. 9	Oct. 21	Oct. 26
0	20.20	19.20	20.55	22.80	26.70	22.70	25.20	24.20	22.90	23.10	22.80	21.60	21.20	21.20	16.95	18.10	13.05	12.80
5	20.00	19.10	20.35	22.80	25.55	22.60	23.90	23.90	22.80	23.00	22.80	21.60	20.95	19.90	16.90	17.90	13.05	12.20
9	19.20	17.60	19.80	22.70	23.70	22.55	23.75	23.80	22.70	22.90	22.60	21.60	20.90	19.60	16.90	17.75	13.00	12.10

Surface temperature varied from a maximum of 26.7° C. on July 8, 1939, to a minimum of 0.2° C., under the ice-cover, during Jan. and Feb., 1939 (Fig. 8). It will be noted that water temperature for a given date did not vary more than 0.5° C. from top to bottom while the ice-cover existed (Table I). A definite ice-cover existed from Jan. 23 to April 1, 1939, at which time water temperature was less than 1.0° C., but as soon as the ice disappeared the temperature increased rapidly to approximately 3.0° C. and continued to increase until the summer maximum was reached.

TURBIDITY

Water in the Bass Islands Region is characterized by sudden changes in turbidity, ranging from 3 to 140 p.p.m. Turbidity is a factor which appears to have a marked influence upon the productivity of the water investigated. Attention is called to Figure 7, which shows graphically the variations in turbidity, based on weekly determinations from Sep-

TABLE II. Turbidity in p.p.m. For Twelve Consecutive Days
During December, 1939

Date	Wind Velocity in m. p. h.	Turbidity in p. p. m.
December 12, 1939...........	10	45
" 13 "	18	70
" 14 "	6	55
" 15 "	6	30
" 16 "	10	20
" 17 "	10	20
" 18 "	3	10
" 19 "	4	10
" 20 "	15	25
" 21 "	20	60
" 22 "	20	70
" 23 "	5	40

tember, 1938, to November, 1939. Unfortunately, the importance of this factor was not realized at the beginning of the investigation; thus, turbidity was determined only once a week and usually on calm days since such days were chosen for general collections. It appears that these data are not truly representative of the average conditions of turbidity, but apparently represent the lower ranges, at least lower than an average based on daily determinations. Daily determinations of turbidity for 12 consecutive days during December, 1939, are recorded in Table 2. These data give a general idea of the degree of variation in turbidity and its relation to wind velocity. Strong winds from the west and northwest, after an extended calm period, may result in a rapid rise in turbidity of 35 p.p.m. or more within 24 hours. When the wind subsides turbidity decreases slowly during the first day due to continued waves and swells resulting from the storm. If several calm days follow in succession a large portion of the suspended material settles out and relatively clear conditions prevail. During the autumn

of 1938 and spring of 1939, there were nearly as many windy days as calm; thus, water in this region was usually quite turbid.

Numerous observations from airplane and motor boat indicate that there is a marked irregularity in distribution of turbid waters in the immediate vicinity of the Bass Islands. Water between Catawba Point and South Bass Island (Fig. 2), known as the South Channel, is often more turbid than water in the area studied. A possible explanation for this fact is that during rainy periods the Portage River, and other rivers along the south shore, discharge highly turbid water into the lake. Some of this water may be carried to various parts of the lake but probably much of it follows along the shore. Often on crossing the South Channel by boat, clear and turbid areas with clearly defined boundaries are encountered, due probably to current action. Likewise, the North Passage, the water between the Canadian shore and the islands, is reported to contain less turbid water than either the South Channel or the Bass Islands Region. This difference is usually attributed to currents which bring in clearer water from the deep eastern end of the lake. It is apparent that the shallow western end of the lake does have highly turbid water most of the year, but it can not yet be stated that certain areas are consistently more turbid than others. It would appear that turbidity was rather uniformly distributed from top to bottom, since turbidity readings at surface, 5 meters, and 9 meters did not show much variation. The lower meter of water was sometimes more turbid than the water above it but usually the difference did not exceed 5 p.p.m.

Microscopic examination of suspended materials causing turbidity reveals fine sand, organic debris, particles of clay, and other sediments. Physical and chemical analyses of these materials are being made at this laboratory for the purpose of determining what role they may play in the cycle of dissolved elements in the water. Also, such a study will aid in tracing the source of sediments responsible for turbidity.

TRANSPARENCY

The maximum Secchi disc reading for the period of investigation was 2.1 meters, February 25, 1939, under the ice-cover; the minimum reading was 0.11 meter on April 5, 1939, shortly after the ice-cover disappeared. Seasonal variation in transparency is shown in Table III, while the averages for the seasons are as follows: September through December, 1938, 0.66 meter; January through March, 1939, 1.3 meters; April through May, 1939, 0.44 meter; June to September, 1939, 1.1 meters; and September to November, 1939, 0.8 meter. Greatest transparency occurred during winter when an ice-cover was present and also during summer months when calm weather prevailed. Lowest transparency existed in spring shortly after the ice disappeared while intermediate conditions prevailed during the autumn months.

Water in the Bass Islands Region is characterized by low transparency, a fact made evident by a comparison of the above data with data derived from investigations of the esatern end of Lake Erie and certain smaller inland lakes. Parameter (1929) reported a maximum Secchi disc reading of 10.5 meters, a minimum 2.0 meters, and an average of 5.0 to 6.0 meters for the eastern end of Lake Erie, from June 15, to September

15, 1928. Average reading for the Bass Island Region for a corresponding period was 1.2 meters. Raymond (1937) who made a year-round study of Bass Lake, Michigan, reported that the Secchi disc readings varied from 4.7 to 5.2 meters, the average being about 5 meters. Tressler (1940) who studied Chautauqua Lake, New York, obtained a maximum

TABLE III. Transparency As Determined By the Secchi Disc

Date	Trans-parency in Meters	Date	Trans-parency in Meters	Date	Trans-parency in Meters
Sept. 2, 1938	0.50	Jan. 10, 1939	1.01	June 5, 1939	1.00
" 7	0.66	" 23	0.84	" 14	0.51
" 16	0.68	Feb. 2	1.40	" 22	0.69
" 23	0.70	" 11	1.17	" 29	1.25
" 28	0.70	" 17	1.87	July 8	1.86
Oct. 5	1.13	" 25	2.15	" 22	1.69
" 12	1.04	Mar. 4	2.00	Aug. 1	1.50
" 17	1.24	" 10	1.92	" 11	0.78
" 26	0.60	" 20	0.92	" 26	1.45
Nov. 1	0.80	" 29	1.08	" 31	1.45
" 5	0.70	Apr. 5	0.11	Sept. 6	1.15
" 10	0.49	" 11	0.13	" 12	0.82
" 17	0.47	" 18	0.40	" 19	0.85
" 22	0.47	" 25	0.25	" 25	1.00
" 29	0.40	May 3	0.50	Oct. 3	0.61
Dec. 5	0.50	" 9	0.46	" 9	1.00
" 15	0.40	" 16	0.80	" 21	0.68
" 19	0.44	" 23	0.85	" 26	0.64
		" 30	1.25		

reading of 5 meters in December, and a minimum of 2.0 meters in August. Many Secchi disc readings higher and lower than those cited above have been reported but these furnish a basis for comparison.

It is realized that determining transparency by means of the Secchi disc is a rough method subject to many errors, but it does give a general idea of transparency and depth of light penetration. Many investigators have used this method alone for determining transparency, and in order to compare this lake with others the same method was used.

When work was begun it was planned to obtain quantitative data in respect to light penetration. The photometer described in the section of this paper under Methods and Equipment was put into operation in September, 1938, at which time it was calibrated. After it had been in use for several months it was again calibrated and was found to be defective. Just when it became defective is not known; consequently, all data collected up to mid-April must be treated only qualitatively. After repair the instrument was recalibrated and put into immediate use obtaining quantitative data. Thus, in this paper, instead of expressing data in terms of total illumination at various depths as a percentage of

TABLE IV.   Maximum Depth of Water, in Meters, At Which the Photometer Recorded Illumination

Date	Depth of Light Penetration in Meters	Date	Depth of Light Penetration in Meters	Date	Depth of Light Penetration in Meters
Sept. 2, 1938	5.0	Nov.17, 1938	4.0	June 29, 1939	6.0
" 7	4.0	" 22	3.0	July 28	9.0
" 16	4.0	Dec. 5	3.0	Aug.26	9.0
" 23	5.0	" 15	3.0	" 31	9.0
" 28	5.0	" 19	2.5	Sept.12	3.0
Oct. 5	4.0	Jan. 10, 1939	3.0	" 19	6.0
" 12	6.5	" 23	4.5	" 25	7.0
" 17	6.5	Feb.11	7.0	Oct. 3	4.0
" 28	4.0	" 17	5.0	" 9	4.5
Nov. 1	4.5	Mar. 4	8.0	" 21	3.0
" 5	4.5	Apr. 5	0.4	" 26	2.5
" 10	4.0	" 11	0.3		

surface light, it has become necessary to state only the greatest depth at which a perceptible light reading could be made with the photometer. The instrument is not sensitive to quantities of light smaller than 1.5 foot candles; therefore, it is assumed that quantities no greater than this existed at depths where no reading could be obtained.

Table IV contains data obtained by the photometer from September, 1938, to November, 1939, expressing in meters the greatest depths at which light was registered by the instrument. According to these data visible light penetrated to a maximum depth of 9.0 meters, a minimum depth of 0.3 meter, and an average depth of 4.7 meters. Average depth

of light penetration for the same periods as discussed for the Secchi disc readings are as follows: September through December, 1938, 4.2 meters; January through March, 1939, 5.5 meters; April, 0.35 meter; June to September, 1939, 8.2 meters; and September to November, 1939, 4.3 meters. In most respects these data correspond closely with those from the Secchi disc readings. Light penetrated to the greatest depths during the time of ice-cover and during the summer months, the least during April, and to intermediate depths from September to November. The effect of an ice-cover on the penetration of daylight into lake water is being investigated, but it will suffice to state here that on several occasions it was found that the ice-cover reflected or absorbed 30 to 50 per cent of the light which fell upon its surface. Until more is known about the influence of an ice-cover on the penetration of daylight into lake water, direct comparisons can not be made between light data obtained through an ice-cover and that obtained in open water.

CHEMICAL DATA

Routine analyses were made at the following depths: surface, 5 meters and 9 meters; however, when marked differences were encountered between these depths additional analyses were made. In general it might be stated that chemical conditions exhibited considerable uniformity from surface to bottom on a given date, but seasonal variations were pronounced. Since vertical distribution of chemical factors is rather uniform it is possible to determine the general chemical conditions by referring to Figure 6, which shows the surface values of each chemical factor investigated.

Dissolved oxygen varied from 5.0 p.p.m. in August and September to 12.9 p.p.m. in March, under the ice-cover (Table V). Variation from surface to bottom did not exceed 2.0 p.p.m. and often it was nearly uniform. Oxygen content of the water was consistently greater during the autumn of 1939, than during the autumn of 1938, which fact can not be explained on the basis of temperature differences (Table I). On several occasions dissolved oxygen showed sudden increases and decreases in content within a period of one week which seems to be related to abundance of organic material in the water, either in the form of plankton or detritus.

Hydrogen-ion concentration (Table VI) varied from 7.5 to 8.4 with the maximum occurring from July to October and the minimum from November to April. From June 14 to 29, the pH was lower than the week preceding or following this period. Irregularities in respect to Ph-th alkalinity, carbon dioxide, and transparency were observed on these same dates. Apparently stormy conditions had stirred up bottom materials, releasing carbon dioxide which brought about the transformation of carbonates into bicarbonates, a lowering of pH, and an increase in turbidity. This one example illustrates how chemical conditions in this region may be altered for short periods by strong winds. No marked variation in vertical distribution of pH was detected despite temporary thermoclines.

TABLE V. Dissolved Oxygen in p. p. m.

Depth in Meters	Sept. 2 1938	Sept. 7	Sept. 16	Sept. 23	Sept. 28	Oct. 5	Oct. 12	Oct. 17	Oct. 28	Nov. 1	Nov. 5	Nov. 10	Nov. 17	Nov. 23	Nov. 29	Dec. 5	Dec. 15	Dec. 19
0	5.50	5.12	7.10	6.74	7.60	7.20	7.40	8.46	9.08	6.00	8.60	8.20	8.80	9.71	9.94	12.10	10.60	9.00
5	5.10	5.24	7.22	7.10	8.00	7.46	8.00	7.60	8.68	6.20	8.30	8.06	9.34	9.50	10.56	10.70	10.60	9.76
9	5.00	4.94	7.08	7.66	8.90	7.24	7.20	7.84	8.80	6.00	8.30	7.94	9.36	9.22		10.20	10.50	9.98

Depth in Meters	Jan. 10 1939	Jan. 23	Feb. 2	Feb. 11	Feb. 17	Feb. 25	Mar. 4	Mar. 10	Mar. 29	Apr. 5	Apr. 11	Apr. 18	Apr. 25	May 3	May 9	May 16	May 23	May 30
0	10.70	11.46	10.20	10.80	12.00	10.80	11.20	10.90	12.94	12.00	11.20	11.80	10.70	10.00	9.94	8.81	9.10	8.70
5		11.56	11.30	11.04	11.24	10.50	11.66	10.72	12.06	12.50	11.94	11.20	10.70	10.40	9.66	8.44	10.60	7.90
9		11.36	11.10	11.36	11.70	12.74	10.06	10.82	12.20	12.54	11.56	11.80	9.80	10.60	9.60	8.96	9.20	7.96

Depth in Meters	June 5 1939	June 14	June 22	June 29	July 8	July 22	Aug. 1	Aug. 11	Aug. 26	Aug. 31	Sept. 6	Sept. 12	Sept. 19	Sept. 25	Oct. 3	Oct. 9	Oct. 21	Oct. 26
0	8.80	7.70	8.45	7.40	7.50	7.80	7.80	7.60	6.70	5.40	5.60	5.40	8.46	9.00	9.20	10.00	9.80	11.00
5	7.70	9.00	7.45	7.06	7.70	7.60	8.60	6.90	5.80	5.20	5.60	5.40	8.20	8.50	8.40	8.20	9.60	8.10
9	8.14	7.00	7.15	6.34	7.80	6.40	6.86	6.90	6.00	5.34	5.70	7.90	8.14	8.50	8.50	8.20	8.60	8.00

TABLE VI. Hydrogen-ion Concentration

Depth in Meters	Sept. 2 1938	Sept. 7	Sept. 16	Sept. 23	Sept. 28	Oct. 5	Oct. 12	Oct. 17	Oct. 28	Nov. 1	Nov. 5	Nov. 10	Nov. 17	Nov. 23	Nov. 29	Dec. 5	Dec. 15	Dec. 19
0	7.9	8.0	8.1	8.1	8.0	8.0	8.0	7.8	7.7	7.7	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.6
5	8.0	8.1	8.1	8.1	8.0	8.0	8.0	7.8	7.7	7.7	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.6
9	7.9	8.1	8.1	8.1	8.0	8.0	8.0	7.8	7.7	7.7	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.6

Depth in Meters	Jan. 10 1939	Jan. 23	Feb. 2	Feb. 11	Feb. 17	Feb. 25	Mar. 4	Mar. 10	Mar. 29	Apr. 5	Apr. 11	Apr. 18	Apr. 25	May 3	May 9	May 16	May 23	May 30
0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.6	7.6	7.6	7.8	7.8	8.2	8.2
5		7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.6	7.6	7.6	7.8	7.8	8.2	8.2
9		7.6	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.6	7.6	7.6	7.8	7.8	8.0	8.2

Depth in Meters	June 5 1939	June 14	June 22	June 29	July 8	July 22	Aug. 1	Aug. 11	Aug. 26	Aug. 31	Sept. 6	Sept. 12	Sept. 19	Sept. 25	Oct. 3	Oct. 9	Oct. 21	Oct. 26
0	8.2	7.8	7.9	8.3	8.4	8.2	8.4	8.2	8.4	8.4	8.4	8.2	8.4	8.4	8.2	8.2	8.2	8.2
5	8.2	7.7	7.8	8.3	8.4	8.2	8.4	8.2	8.4	8.4	8.4	8.2	8.4	8.3	8.2	8.2	8.2	8.2
9	8.2	7.6	7.7	8.2	8.4	8.2	8.2	8.2	8.4	8.4	8.4	8.2	8.2	8.2	8.2	8.2	8.2	8.2

TABLE VII. Free Carbon Dioxide in p. p. m.

Depth in Meters	Sept. 2 1938	Sept. 7	Sept. 16	Sept. 23	Sept. 28	Oct. 5	Oct. 12	Oct. 17	Oct. 28	Nov. 1	Nov. 5	Nov. 10	Nov. 17	Nov. 23	Nov. 29	Dec. 5	Dec. 15	Dec. 19
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.11	0.45
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.45
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.90	0.45

Depth in Meters	Jan. 10 1939	Jan. 23	Feb. 2	Feb. 11	Feb. 17	Feb. 25	Mar. 4	Mar. 10	Mar. 29	Apr. 5	Apr. 11	Apr. 18	Apr. 25	May 3	May 9	May 16	May 23	May 30
0	0.40	0.60	0.60	0.60	0.60	0.70	0.60	0.60	0.60	2.90	2.10	0.70	0.90	0.60	0.50	0.0	0.0	0.0
5		0.60	0.60	0.60	0.60	0.70	0.60	0.60	0.60	2.90	2.10	0.70	0.90	0.60	0.50	0.0	0.0	0.0
9	0.60	0.60	0.60	0.60	0.60	0.70	0.60	0.60	0.60	2.90	2.10	0.70	0.90	0.70	1.00	0.0	0.0	0.0

Depth in Meters	June 5 1939	June 14	June 22	June 29	July 8	July 22	Aug. 1	Aug. 11	Aug. 26	Aug. 31	Sept. 6	Sept. 12	Sept. 19	Sept. 25	Oct. 3	Oct. 9	Oct. 21	Oct. 26
0	0.0	0.20	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.90	0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.90	0.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE VIII. Ph-th Alkalinity in p. p. m.

Depth in Meters	Sept. 2 1938	Sept. 7	Sept. 16	Sept. 23	Sept. 28	Oct. 5	Oct. 12	Oct. 17	Oct. 28	Nov. 1	Nov. 5	Nov. 10	Nov. 17	Nov. 23	Nov. 29	Dec. 5	Dec. 15	Dec. 19
0	1.10	1.70	3.40	2.50	2.50	3.90	3.00	3.20	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.90	1.30	2.70	2.20	2.50	3.70	3.20	3.30	0.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	1.40	1.10	3.20	1.70	2.70	3.80	3.70	3.90	0.80	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0

Depth in Meters	Jan. 10 1939	Jan. 23	Feb. 2	Feb. 11	Feb. 17	Feb. 25	Mar. 4	Mar. 10	Mar. 29	Apr. 5	Apr. 11	Apr. 18	Apr. 25	May 3	May 9	May 16	May 23	May 30
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.00	0.50
5		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.30	0.50
9		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50

Depth in Meters	June 5 1939	June 14	June 22	June 29	July 8	July 22	Aug. 1	Aug. 11	Aug. 26	Aug. 31	Sept. 6	Sept. 12	Sept. 19	Sept. 25	Oct. 3	Oct. 9	Oct. 21	Oct. 26
0	1.00	0.0	0.0	2.00	3.00	1.00	3.00	2.30	2.40	2.50	2.50	4.00	4.40	1.30	0.0	1.00	0.0	0.0
5	1.00	0.0	0.0	1.90	3.00	1.00	3.00	2.30	2.40	2.50	2.00	4.00	4.40	1.30	0.0	1.00	0.0	0.0
9	1.00	0.0	0.0	1.80	3.00	1.00	3.00	2.30	2.50	2.50	2.00	4.00	4.40	1.30	0.0	1.00	0.0	0.0

TABLE IX. Methyl Orange Alkalinity in p. p. m.

Depth in Meters	Sept. 2 1938	Sept. 7	Sept. 16	Sept. 23	Sept. 28	Oct. 5	Oct. 12	Oct. 17	Oct. 28	Nov. 1	Nov. 5	Nov. 10	Nov. 17	Nov. 23	Nov. 29	Dec. 5	Dec. 15	Dec. 19
0	95.00	96.90	92.30	92.30	92.40	93.80	94.20	92.70	96.00	93.00	94.50	90.80	92.20	91.70	92.50	90.20	93.40	92.80
5	95.50	96.10	92.00	91.70	92.10	93.40	94.10	92.60	95.50	93.00	93.00	89.80	92.30	92.10	92.50	89.80	93.80	92.40
9	96.00	95.50	91.50	91.30	92.40	92.30	92.70	93.30	93.80	92.50	93.10	90.00	92.40	91.60		90.00	93.90	93.30

Depth in Meters	Jan. 10 1939	Jan. 23	Feb. 2	Feb. 11	Feb. 17	Feb. 25	Mar. 4	Mar. 10	Mar. 29	Apr. 5	Apr. 11	Apr. 18	Apr. 25	May 3	May 9	May 16	May 23	May 30
0	86.30	85.00	84.60	86.00	84.00	83.20	82.00	82.60	86.00	85.50	84.20	83.30	84.80	83.30	89.80	89.10	93.20	88.20
5		85.00	84.50	84.30	82.00	82.10	83.00	83.40	86.00	85.50	84.20	83.30	85.20	85.70	88.70	87.40	91.80	89.30
9	85.00	85.00	84.50	84.20	84.00	83.40	82.00	82.00	86.00	85.50	84.20	87.00	84.80	86.50	87.00	88.80	88.50	91.50

Depth in Meters	June 5 1939	June 14	June 22	June 29	July 8	July 22	Aug. 1	Aug. 11	Aug. 26	Aug. 31	Sept. 6	Sept. 12	Sept. 19	Sept. 25	Oct. 3	Oct. 9	Oct. 21	Oct. 26
0	92.40	88.30	90.70	89.00	89.20	89.00	92.30	92.20	92.50	92.00	91.50	92.50	91.00	91.00	88.00	88.10	91.30	92.00
5	92.20	91.00	89.20	91.00	90.00	88.00	92.30	92.20	93.00	92.00	92.00	92.50	91.00	91.00	88.00	88.10	91.30	92.00
9	92.00	93.70	91.00	89.00	91.00	88.00	92.30	92.20	93.00	92.00	92.00	92.50	91.00	91.00	88.00	88.10	91.30	92.00

Free carbon dioxide varied from 0.0 to 2.9 p.p.m. from September, 1938, to November, 1939 (Table VII). In general it might be stated that free carbon dioxide was present from December to May and was nearly absent the rest of the year. The maximum carbon dioxide value occurred in April, 1939, during the stormy period which followed the disappearance of the ice-cover. Vertical distribution was almost uniform from surface to bottom for a given date irrespective of season.

Alkalinity of water in the Bass Islands Region (Tables VIII and IX) is due almost entirely to bicarbonates which varied from 96.9 p.p.m. in September, 1938, to 82.0 p.p.m. in March, 1939. In general bicarbonates were present in smaller quantities from January to May than during the rest of the year. Vertical distribution of bicarbonates varied as much as 4.0 p.p.m. from surface to bottom on a given date; however, for the period of investigation it is not possible to state that bicarbonates at one depth were consistently higher or lower than at other depths. Carbonates were absent from September, 1938, to late May, 1939. When present carbonates varied from a minimum of 0.5 p.p.m. in June to a maximum of 4.4 p.p.m. in September.

PLANKTON DATA

PHYTOPLANKTON

Seasonal Distribution

TOTAL PHYTOPLANKTON

All data pertaining to seasonal distribution and relative abundance of phytoplankton have been derived from an average of collections made from surface, 5 meters, and 9 meters, on a given date. A collection consisted of samples taken from the above depths at one place within the area studied; however, not all collections were made at the same location but were distributed throughout the area from time to time. Nevertheless, all data herein treated have been considered as having come from one station.

General features of seasonal distribution and relative abundance of total phytoplankton are shown in Figure 7 and Table X. It will be noted that definite pulses occurred during the autumn of 1938, and spring of 1939, and again in the autumn of 1939. Pulses of these three periods were approximately of the same size as indicated by the following maxima: autumn of 1938, 330,000 units per liter; spring 1939, 247,000 units per liter; and autumn of 1939, 320,000 units per liter. Duration of the three pulses were as follows: autumn of 1938, 6 weeks; spring of 1939, 8 weeks; and the autumn of 1939, 11 weeks. It should be noted that the entire spring pulse of 1939 occurred under an ice-cover. Fluctuations in quantity of phytoplankton occurred within individual pulses, concerning which no positive explanation can be offered. Data on turbidity (Fig. 7) strongly suggest that many of the fluctuations in quantity of phytoplankters are related to fluctuations in turbidity. However, it is possible that uneven horizontal distribution of phytoplankton within the area may account for these irregularities.

The following list of phytoplankters represents those encountered during quantitative studies, from September 2, 1938, to November 1, 1939. Tiffany (1934) published a qualitative list of plankton algae of this region; thus, the present paper includes only those forms which occurred in sufficient numbers to be considered significant quantitatively. Since identification to species was not practicable in many instances,
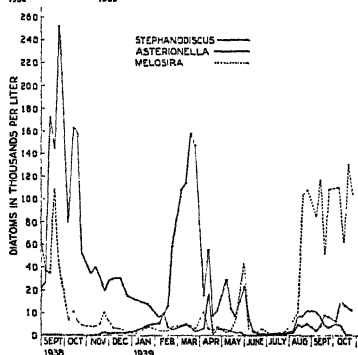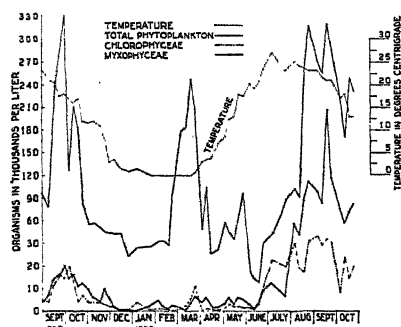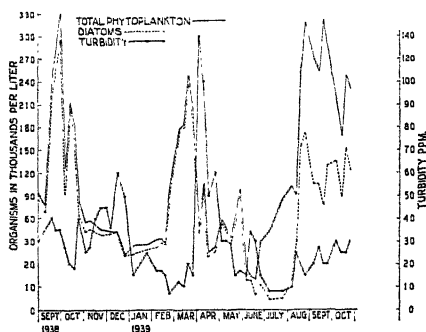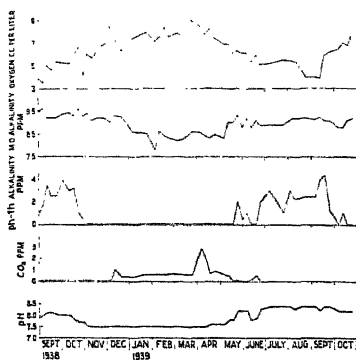
Fig. 6 (upper left). Graphs showing chemical values at the surface for dissolved oxygen, methyl orange alkalinity, Ph-th alkalinity, free carbon dioxide, and pH.

Fig. 7 (upper right). Graphs showing the standing crop of total phytoplankton and total diatoms, in thousands of units per liter, and turbidity in p.p.m.

Fig. 8 (lower left). Graphs showing the standing crop of total phytoplankton, total Chlorophyceae, and total Myxophyceae, in thousands of units per liter, and surface temperature in degrees centigrade.

Fig. 9 (lower right). Graphs showing the standing crop of *Stephanodiscus*, *Asterionella*, and *Melosira*, in thousands of units per liter.

only genus is given. This list consists of 86 algal forms, distributed among the classes as follows: Myxophyceae 17, Chrysophyceae 4, Heterophyceae 2, Bacillariales 23, and Chlorophyceae 40. These forms constituted at least 95 per cent of the total quantity of phytoplankton over the period of investigation. In the following discussion information is given concerning seasonal distribution and relative abundance of the major groups and the more important phytoplankters.

TABLE X.   Abundance of Centrifuged Phytoplankton in Thousands, of Units per Liter

Depth in Meters	Group	Sept. 2 1938	Sept. 7	Sept. 16	Sept. 23	Sept. 28	Oct. 5	Oct. 12	Oct. 17	Oct. 28	Nov. 1	Nov. 5	Nov. 10	Nov. 17	Nov. 23	Dec. 5	Dec. 15	Dec. 19	Jan. 10 1939
0	Myxophyceae..	4.2	7.0	10.4	17.5	20.3	19.6	16.1	10.6	14.7	12.8	5.0	4.3	9.3	6.8	1.8	0.0	1.2	0.0
	Bacillariales...	87.5	60.4	174.3	266.7	257.6	89.7	185.4	101.6	67.2	31.2	43.4	44.4	30.0	38.9	32.2	31.2	19.3	23.7
	Chlorophyceae	7.0	3.5	9.8	13.3	13.3	19.6	14.0	4.3	4.5	3.2	5.6	4.3	1.2	5.6	3.7	0.0	0.0	4.3
	Miscellaneous.	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total.......	98.7	72.3	194.5	297.5	291.2	128.9	215.5	116.5	86.4	47.2	54.0	53.0	40.5	51.3	37.7	31.2	20.5	28.0
5	Myxophyceae..	2.8	9.1	17.5	12.6	20.3	14.7	12.6	15.0	8.7	6.8	5.0	4.3	9.3	3.7	2.1	0.0	0.0	
	Bacillariales...	82.2	68.2	212.1	255.9	309.4	99.9	180.6	214.6	63.2	46.5	40.6	41.2	34.3	39.0	37.8	53.7	26.2	
	Chlorophyceae	2.8	4.2	7.7	16.1	20.3	25.2	16.1	2.5	7.7	8.1	2.5	3.1	1.2	7.5	0.6	0.0	0.0	
	Miscellaneous.	1.4	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Total.......	89.2	81.5	238.7	284.6	350.0	139.8	209.3	232.1	79.6	61.4	48.1	48.6	44.8	50.2	40.5	53.7	26.2	
9	Myxophyceae..	4.2	4.2	12.6	17.5	18.9	8.4	19.7	7.5	12.6	9.3	8.7	4.3	10.0	6.2	1.5	0.0	0.0	
	Bacillariales...	90.2	72.8	239.4	247.8	320.6	86.2	181.1	186.5	56.1	43.1	53.0	40.3	34.2	31.9	47.2	45.9	25.6	
	Chlorophyceae	3.5	3.5	16.1	18.2	9.8	14.7	10.5	5.6	8.4	1.8	4.3	5.6	7.4	1.8	1.8	0.0	0.0	
	Miscellaneous.	0.0	1.4	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Total.......	97.9	81.9	276.5	283.5	349.3	109.3	211.3	199.6	77.1	54.2	66.0	50.2	51.6	39.9	50.5	45.9	25.6	

TABLE X—(Continued)

Depth in Meters	Group	Jan. 23 1939	Feb. 2	Feb. 11	Feb. 17	Feb. 25	Mar. 4	Mar. 10	Mar. 20	Mar. 29	Apr. 5	Apr. 11	Apr. 18	Apr. 25	May 3	May 9	May 16	May 23	May 30
0	Myxophyceae..	2.5	0.6	2.7	0.6	1.8	1.2	0.6	4.3	7.5	2.4	4.1	1.8	1.4	3.1	5.4	5.8	8.9	7.5
	Bacillariales...	27.1	25.1	29.8	29.0	103.3	158.4	176.8	237.7	188.1	39.3	91.6	23.6	27.7	49.4	31.8	33.1	59.1	94.9
	Chlorophyceae	1.2	0.6	0.6	0.0	0.6	1.2	2.5	6.8	15.0	0.0	5.0	0.0	0.0	1.6	4.3	2.6	2.5	1.2
	Miscellaneous.	0.6	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total........	31.4	26.3	33.7	29.6	105.7	160.8	179.9	248.8	210.6	41.7	100.7	25.4	29.1	54.1	41.5	41.5	70.5	103.6
5	Myxophyceae..	2.5	10.0	2.5	1.8	4.3	2.0	0.6	2.0	4.3	2.4	5.3	1.9	1.8	1.8	8.1	3.0	5.6	2.0
	Bacillariales...	25.6	26.2	30.9	23.4	111.3	195.2	173.1	242.4	190.9	51.2	95.9	24.3	22.5	60.0	26.8	27.4	56.8	85.2
	Chlorophyceae	0.0	1.2	1.8	0.6	0.0	1.8	3.1	5.0	10.0	0.0	0.0	0.0	0.0	1.2	2.5	1.4	2.7	0.6
	Miscellaneous.	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total........	28.1	38.0	35.2	25.8	115.6	199.0	176.8	249.4	205.2	53.6	101.2	26.2	24.3	63.0	37.4	31.8	65.1	87.8
9	Myxophyceae..	1.2	2.5	1.2	1.2	1.2	1.2	0.0	4.3	7.5	3.7	7.8	1.2	2.0	4.4	3.7	0.8	3.7	6.2
	Bacillariales...	24.7	29.4	28.5	29.0	99.2	173.7	187.9	234.2	185.0	40.3	107.2	22.5	26.2	51.8	41.3	26.8	46.7	86.5
	Chlorophyceae	0.6	1.2	0.6	0.6	0.0	0.0	2.5	5.6	8.7	0.0	0.0	0.6	0.0	1.8	2.5	1.4	0.6	2.6
	Miscellaneous.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total........	26.5	33.1	30.3	30.8	100.4	174.9	190.4	244.1	201.2	44.0	115.0	24.3	28.2	58.0	47.5	29.0	51.0	95.3

TABLE X—(Continued)

Depth in Meters	Group	June 5 1939	June 14	June 22	June 29	July 8	July 22	Aug. 1	Aug. 11	Aug. 26	Aug. 31	Sept. 6	Sept. 12	Sept. 19	Sept. 25	Oct. 3	Oct. 9	Oct. 21	Oct. 26
0	Myxophyceae	3.1	1.2	2.2	9.0	12.5	65.7	85.3	40.7	179.3	124.6	125.2	102.0	202.3	113.2	106.6	79.6	78.4	97.2
	Bacillariales	14.1	18.3	5.5	11.5	4.3	9.5	13.6	14.6	57.0	126.5	103.0	132.6	66.6	79.6	120.9	75.5	143.5	108.5
	Chlorophyceae	1.2	1.2	5.6	9.3	21.2	15.9	43.6	18.1	17.7	32.4	65.4	36.5	35.9	31.8	11.8	24.6	35.4	23.5
	Miscellaneous	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	18.4	20.7	13.3	30.4	38.0	91.1	142.5	73.4	255.1	283.5	293.6	271.1	304.8	224.6	239.3	179.7	257.3	229.2
5	Myxophyceae	3.7	0.6	3.3	10.6	21.6	42.5	58.4	42.9	56.0	141.9	96.5	67.4	235.7	120.9	67.2	46.2	63.7	84.3
	Bacillariales	11.3	10.2	4.7	9.5	3.7	2.4	12.3	23.2	180.5	168.9	104.3	145.7	87.2	134.4	142.7	88.8	141.4	111.5
	Chlorophyceae	1.2	0.6	3.7	10.1	19.3	25.2	38.9	19.4	20.0	28.2	20.6	26.5	39.3	33.0	15.3	24.7	16.5	23.0
	Miscellaneous	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.5	1.8	0.0	0.0	0.0	0.0
	Total	16.2	11.4	11.7	30.8	44.6	70.1	109.6	85.5	258.2	339.0	221.4	239.6	362.7	290.1	225.2	159.7	221.6	218.8
9	Myxophyceae	1.4	1.2	2.5	6.8	13.3	76.9	25.3	38.2	26.5	69.7	74.3	84.9	182.4	114.5	53.1	46.6	83.3	71.3
	Bacillariales	12.2	9.3	8.7	11.3	5.0	2.6	11.9	44.1	224.0	223.0	112.0	138.0	76.1	175.2	141.3	102.1	160.0	153.3
	Chlorophyceae	2.5	0.6	4.3	10.6	27.5	17.7	12.9	20.2	14.1	37.7	32.2	23.6	34.1	30.0	17.6	23.6	23.6	15.3
	Miscellaneous	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0
	Total	16.1	11.1	15.5	28.7	45.8	97.2	50.1	102.5	264.6	330.4	218.5	246.5	294.4	319.7	212.0	172.3	266.9	239.9

MYXOPHYCEAE

This group was relatively unimportant qualitatively and quantitatively during the first 10 months of investigation, but it became very important quantitatively during the summer and autumn of 1939 (Fig. 8). The average number of units in thousands per liter of this group from September 2 to December 5, 1938, was 10.5; from December 5, 1938, to July 22, 1939, 3.0; and from July 22, to November 1, 1939, 87.3. At no time from September, 1938, to late June, 1939, did the members of this group exceed 20,000 units per liter, and only during September and October of this period was there any indication of a pulse. Late summer and early autumn of 1939 were characterized by large numbers of this group, a maximum of 210,000 units per liter occurring in late September. The contrast in quantity of this group during the two autumns again suggests the influence of turbidity on plankton production.

Anabaena sp. Occurred during summer and autumn, in quantities not exceeding 2,000 units per liter.

Aphanizomenon flos-aquae (L.) Ralfs, and *Oscillatoria* sp., have been grouped in this study, due to the difficulty of distinguishing one from the other while making the quantitative counts. They were present in most collections and were more numerous than any other members of Myxophyceae. These two forms appeared in quantities varying from 1,000 to 8,000 units per liter from September to December, 1938, with the maximum occurring in September. From January to July, 1939, these forms did not exceed 1,000 units per liter, but a definite pulse began in August and reached a maximum of 104,000 units per liter in late September, 1939.

Aphanocapsa sp. Found in a few collections during August and September, 1939, but never exceeded 2,000 units per liter.

Aphanothece sp. Occurred in the collections of August, 1939, but did not exceed 3,000 units per liter.

Chroococcus limneticus Lemmermann.

Chroococcus turgidus (Kütz.) Näg. No attempt was made to separate *Chroococcus* species in counting. Two peaks of production appeared, October and November, 1938, and July through August, 1939, but they did not exceed 5,000 units per liter.

Coelosphaerium dubium Grunow.

Coelosphaerium naegelianum Unger. No attempt was made to separate these two species in counting. Found during September, 1938, and in July, August, and September, 1939, but in quantities less than 4,000 units per liter.

Gloeotrichia sp. Present in two collections of July, 1939, not exceeding 1,000 units per liter.

Gomphosphaeria lacustris Chodat. Occurred during August and September, 1939, in quantities less than 1,000 units per liter.

Lyngbya sp. Rare.

Merismopedia elegans A. Braun.

Merismopedia glauca (Ehr.) Näg.

Merismopedia tenuissima Lemmermann. Species of *Merismopedia* were not separated in counting. This genus occurred only from Septem-

ber to November, 1938, and from August to late October, 1939. A maximum of 15,000 units per liter occurred in September, 1939.

Microcystis aeruginosa Kütz.

Microcystis flos-aquae (Wittr.) Kirchner. In counting, no attempt was made to separate the different species of *Microcystis*. This genus showed two peaks of production: the first in September, 1938, with a maximum of 7,700 units per liter; the second in August, 1939, with a maximum of 46,000 units per liter. The occurrence of irregular numbers of this genus from week to week explains to a large degree the irregularities of the graph for total Myxophyceae (Fig. 8).

Oscillatoria sp. This form is discussed with *Aphanizomenon*.

CHRYSOPHYCEAE

Dinobryon divergens Imhof.

Dinobryon sertularia Ehr. No attempt was made to separate the species of *Dinobryon*. This genus occurred during spring and summer of 1939, in quantities not exceeding 2,000 units per liter.

Mallomonas alpina Pascher and Ruttner.

Mallomonas caudata Iwanoff. This genus was found only in June, 1939, and did not exceed 1,000 units per liter.

HETEROPHYCEAE

Botryococcus sp. Found in quantities not exceeding 1,000 units per liter from May to October, 1939.

Tribonema sp. Occurred from July to October, 1939, but did not exceed 800 units per liter.

BACILLARIALES

The following statements summarize the general features of this group (Fig. 7): (1) Diatoms were always present and usually constituted the major portion of each collection. (2) Total diatoms exhibited definite pulses during the autumn of 1938, spring 1939, and autumn of 1939. (3) In general diatoms belonging to the order Centrales (*Melosira, Cyclotella*, and *Stephanodiscus*) were most numerous in autumn, and those belonging to the order Pennales (*Tabellaria, Diatoma, Fragilaria, Synedra*, and *Asterionella*) were most abundant in spring (Fig. 9). (4) Size and duration of the three diatom pulses were as follows: autumn pulse of 1938, 6 weeks with a maximum of 295,000 units per liter; spring pulse of 1939, 8 weeks with a maximum of 238,000 units per liter; and the autumn of 1939, 11 weeks with a maximum of 175,000 units per liter. A comparison of size and duration of diatom pulses with that of total phytoplankton reveals many similarities (Fig. 7). (5) A winter minimum of 20,000 units per liter occurred in December, 1938, and a summer minimum of 4,000 units per liter occurred in July, 1939. (6) Within each pulse appeared fluctuations in number which apparently are related to fluctuations in turbidity. (7) The spring pulse of 1939 appeared while the ice-cover was present. (8) The maximum of the autumn pulse of 1939 was only 60 per cent of the autumn maximum of 1938. Higher turbidity during the former autumn may be partly responsible for this difference. (9) Average number of diatoms in

thousands of units per liter during pulses and between pulses was as follows: September to November, 1938, 157.7; November, 1938, to March, 1939, 33.5; March to April 18, 1939, 146.8; April 18 to August 25, 1939, 29.0; August 25 to November, 1939, 120.0.

Amphiprora sp. Occurred during spring in quantities less than 1,000 units per liter.

Asterionella sp. During the 14 months of investigation this form showed only one pulse which occurred during February, March, and April, 1939, with a maximum of 158,000 units per liter in March (Fig. 9). During the autumn of 1938, it was nearly absent and in the autumn of 1939 it did not exceed 16,000 units per liter.

Cocconeis placentula Ehr. Occurred in spring and autumn collections but did not exceed 1,200 units per liter.

Cyclotella sp. Found in quantities less than 1,000 units per liter during the autumn of 1938, but it appeared during the autumn of 1939, with a maximum of 8,000 units per liter.

Cymatopleura elliptica (Bréb.) W. Smith. Rare.

Cymbella sp. Found only during spring of 1939, in quantities less than 1,000 units per liter.

Diatoma sp. Present in quantities not exceeding 1,000 units per liter during the autumn of 1938, and spring of 1939.

Encyonema sp. Found occasionally in spring collections. Rare.

Fragilaria crotonensis Kitton.

Fragilaria sp. In counting, no attempt was made to separate the different species of *Fragilaria*. This genus was present in most collections and appeared in two pulses, one in March, 1939, with a maximum of 12,000 units per liter, and a second in October, 1939, with a maximum of 8,000 units per liter. Nothing comparable to a pulse occurred in the autumn of 1938.

Gomphonema acuminatum Ehr. Found occasionally in autumn collections, but did not exceed 1,000 units per liter.

Gyrosigma sp. Found throughout the year but did not exceed 1,200 units per liter.

Melosira distans (Ehr.) Kütz.

Melosira granulata (Ehr.) Ralfs.

Melosira varians Ag. In counting, no attempt was made to separate the different species of *Melosira*. This genus reached a maximum of 112,000 units per liter during a pulse in September, 1938, and in June, 1939, another pulse appeared with a maximum of 45,000 units per liter, and finally a pulse extending from August to November, 1939, reached a maximum of 132,000 units per liter. During intervals between pulses this genus was nearly absent (Fig. 9).

Navicula sp. Present in most collections but did not exceed 3,000 units per liter.

Nitzschia sp. Rare.

Rhizosolenia eriensis H. L. Smith. Due to its transparent nature accurate counts of this form could not be made. Apparently it was most abundant from February to June, 1939.

Stephanodiscus spp. This genus showed a pulse in the autumn of 1938, with a maximum of 251,000 units per liter (Fig. 9) and was char-

acterized by abrupt increases and decreases throughout its duration. This form constituted approximately 95 per cent of the total phytoplankton during this period. A small pulse appeared in April, 1939, and again in the autumn of 1939; however, neither of these last two pulses exceeded 18,000 units per liter.

Surirella spp. Found during autumn and spring in quantities not exceeding 1,800 units per liter.

Synedra spp. Two peaks of production appeared, one in March, 1939, with maximum of 48,000 units per liter, and a second in August, 1939, with a maximum of 20,000 units per liter. A secondary pulse with a maximum of 12,000 units per liter appeared in late May, 1939, but it existed for only two weeks.

Tabellaria fenestrata (Lyngbya) Kütz.

Tabellaria flocculosa (Roth) Kütz. This genus was apparently absent from the plankton except from January to June, 1939. It showed only one pulse which occurred in early March, 1939, with a maximum of 11,000 units per liter.

CHLOROPHYCEAE

This group was relatively unimportant quantitatively throughout the period of investigation except during the summer and autumn of 1939. Qualitatively it was one of the most important groups exceeding all others by at least 16 forms. Data on seasonal distribution of total Chlorophyceae (Fig. 8) show that this group produced a small pulse from September to November, 1938, with a maximum of 20,000 units per liter, and another from June to October, 1939, with a maximum of 39,000 units per liter in September. The average number of units in thousands per liter during pulses and periods between pulses was as follows: September to December, 1938, 11.8; December, 1938, to July, 1939, 2.6; and from July to November, 1939, 24.0. Like Myxophyceae this group was more abundant during the autumn of 1939, than in the autumn of 1938.

Actinastrum gracillimum G. M. Smith.

Actinastrum hantzchii Lagerheim. Species of the genus *Actinastrum* were not separated in counting. These forms occurred only in the autumn collections and never exceeded 6,000 units per liter.

Ankistrodesmus convolutus Corda.

Ankistrodesmus falcatus (Corda) Ralfs.

Ankistrodesmus falcatus var. *spirilliformis* G. S. West. In counting, no attempt was made to separate the different species of *Ankistrodesmus*. This genus occurred in quantities not exceeding 1,600 units per liter in the autumn of 1938, but during February and March, 1939, when the ice-cover was present, it reached a maximum of 10,000 units per liter.

Closteriopsis longissima Lemmermann. Found in quantities less than 1,000 units per liter in summer and autumn.

Closterium spp. Occurred in numbers less than 700 units per liter during spring and summer.

Coelastrum microporum Näg.

Coelastrum sp. This genus appeared in about 50 per cent of the collections and was most abundant during the autumn of 1938, with a

maximum of 1,400 units per liter, and again during the summer and autumn of 1939, with a maximum of 1,000 units per liter.

Cosmarium spp. Occurred irregularly during spring and summer but never exceeded 600 units per liter.

· *Crucigenia irregularis* Wille.

Crucigenia rectangularis (Näg.) Gay. The genus *Crucigenia* occurred only during September and October, 1938, in quantities not exceeding 1,200 units per liter.

Dictyosphaerium spp. Occurred in two pulses, the first from September to November, 1938, with a maximum of 7,000 units per liter, and a second from late June to mid-November, 1939, with a maximum of 32,000 units per liter. It was apparently absent except for these two periods.

Gloeocystis sp. Rare.

Kirchneriella obesa (W. West) Schmidle. Found during spring, summer, and autumn but never in quantities exceeding 2,000 units per liter.

Lagerheimia citiriformis (Snow) G. M. Smith. Occurred during summer and autumn, 1939, in quantities not exceeding 600 units per liter.

Oöcystis borgei Snow.

Oöcystis elliptica W. West.

Oöcystis lacustris Chodat.

Oöcystis submarina Lagerheim. In counting, no attempt was made to separate the different species of *Oöcystis*. This genus appeared during summer and autumn, being most abundant in the autumn, but never exceeding 20,000 units per liter.

Pediastrum boryanum (Turpin) Meneghini.

Pediastrum duplex Meyen.

Pediastrum simplex var. *duodenarium* (Bailey) Rabenhorst.

Pediastrum tetras (Ehr.) Ralfs. In counting, no attempt was made to keep the different species of *Pediastrum* separate. This genus appeared in about 50 per cent of the collections but it did not exceed 5,000 units per liter at anytime. Small pulses occurred during the autumns of 1938 and 1939.

Quadrigula closterioides (Bohlin) Printz.

Quadrigula sp. This genus occurred during the autumns of 1938 and 1939, in quantities not exceeding 700 units per liter.

Scenedesmus acuminatus (Lagerheim) Chodat.

Scenedesmus arcuatus Lemmermann.

Scenedesmus bijuga (Turpin) Lagerheim.

Scenedesmus bijuga var. *flexuosus* (Lemmermann) Collins.

Scenedesmus dimorphus (Turpin) Kütz.

Scenedesmus quadricauda (Turpin) Bréb. In counting, the various species of *Scenedesmus* were not kept separate. This genus occurred in most collections but it never exceeded 3,000 units per liter. It was most abundant during late summer and early autumn.

Schroederia setigera (Schroeder) Lemmermann. Appeared irregularly throughout the year with a pulse occurring from July to September, 1939, with a maximum of 13,000 units per liter.

Selenastrum bibraianum Reinsch. Found only in autumn collections, but did not exceed 1000 units per liter.

Sorastrum spinulosum Näg. Occurred in summer and autumn, with a maximum of 1,600 units per liter.

Sphaerocystis schroeteri Chodat. Rare.

Staurastrum paradoxum Meyen. Rare.

Tetraedron sp. Found during summer months in quantities not exceeding 1,000 units per liter.

Westella botryoides (W. West) de Wildemann.

Westella linearis G. M. Smith. The genus *Westella* appeared in the summer plankton but never exceeded 3,000 units per liter.

Per Cent Composition

Composition and relative abundance of phytoplankton for individual collections, from September, 1938, to October, 1939, are shown in Figure 10. The following is a brief analysis of the seasonal variation in
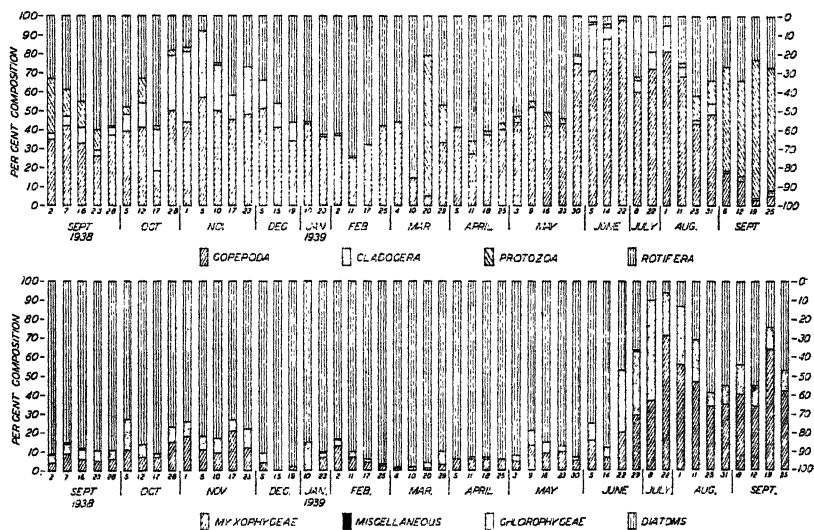
Fig. 10. Graphs showing per cent composition of phytoplankton and zooplankton for individual collections.

composition of this plankton: (1) Diatoms constituted from 5 to 100 per cent of individual collections and were the predominant forms throughout the period of investigation. (2) Diatoms composed at least 70 per cent of the total phytoplankton from September, 1938, to June 22, 1939, and in many instances during this period they constituted 85 to 100 per cent. (3) From June 22, to August 25, 1939, diatoms composed 5 to 48 per cent of the total phytoplankton. (4) From August 25, to September 25, 1939, diatoms made up 25 to 58 per cent of individual collections. (5) Diatoms were not nearly as important a constituent of the plankton during the autumn of 1939, as during the autumn of 1938. (6) Chlorophyceae made up less than 20 per cent, often less than 10 per cent, of individual collections except during the summer months

when it averaged 40 per cent of each collection. (7) Myxophyceae composed less than 20 per cent of each collection from September, 1938, to June 29, 1939, but from July to October, 1939, it composed from 30 to 70 per cent of each collection. (8) Myxophyceae and Chlorophyceae in contrast to Bacillariales were more important constituents of the plankton during the autumn of 1939, than during the autumn of 1938. (9) The miscellaneous group, all phytoplankters not belonging to Bacillariales, Chlorophyceae, and Myxophyceae, did not constitute more than 2 per cent of any collection.

Horizontal and Vertical Distribution

No attempt has been made to determine the nature of horizontal distribution of the phytoplankton within the area studied. As previously stated all plankton data in this paper have been derived from weekly collections made at various locations within a limited area. The fact that these data show consistent trends in respect to seasonal variation of plankton groups as well as individuals, indicates that within the area studied horizontal distribution is quite uniform. It is realized that until a systematic study of this subject is made it will not be advisable to apply the present data to areas not covered in this study.

Differences in abundance of phytoplankton at different depths, in the area studied, were found; however, these differences were not great and not consistently of the same nature (Table X). Data in Table X show that at times the greatest quantity of phytoplankton occurs at the surface, while at other times it is most abundant at 5 meters, and still at other times it is greatest at 9 meters. Even Myxophyceae which normally appears in greatest abundance at or near the surface of most lakes, was the most abundant in many instances at the 9-meter depth. This irregular vertical distribution seems to prevail during spring and autumn when complete circulation is continuous, but under the ice-cover and during mid-summer when circulation is not so evident there are indications that phytoplankters are more consistent in their vertical distribution (Table X). Since vertical distribution of phytoplankton in the Bass Islands Region is irregular it is believed that an average of collections from the three chosen depths gives adequate data to determine the standing crop for a given date.

ZOOPLANKTON

Seasonal Distribution

TOTAL ZOOPLANKTON

Most data pertaining to zooplankton have been derived from an average of the collections made at the surface, 5 meters, and 9 meters on a given date. Previous work in this region has shown that this method furnishes reliable data in respect to the standing crop. However, studies based on collections at intervals of 1 meter from surface to bottom are in progress and will furnish information on vertical distribution which is lacking in this paper.

Seasonal trends of the standing crop of total zooplankton is shown in Figure 11. This graph reveals that a pulse occurred during the

autumn of 1938, and extended to mid-December; the spring pulse of 1939 occurred from mid-April to late June; the autumn pulse of 1939 appeared from August to October. The maximum of the autumn pulse of 1938 apparently occurred before this investigation began, but there are reasons for believing that this pulse was similar to that of the autumn of 1939, except that it appeared a few weeks earlier. The spring
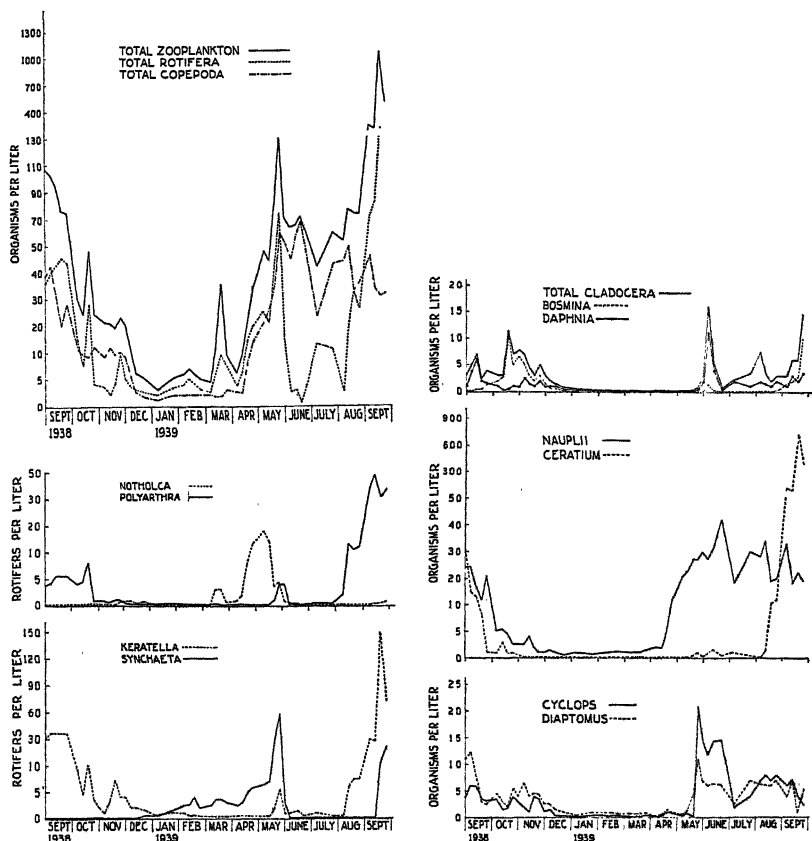
Fig. 11 (upper left). Graphs showing the standing crop of total zooplankton, total Rotifera, and total Copepoda per liter.

Fig. 12 (lower right). Graphs showing the standing crop of *Notholca,· Polyarthra, Keratella,* and *Synchaeta* per liter.

Fig. 13 (right). Graphs showing the standing crop of *Bosmina, Daphnia,* Nauplii, *Ceratium, Cyclops, Diaptomus,* and total Cladocera per liter.

zooplankton pulse of 1939 began at the termination of the spring phytoplankton pulse and reached its peak in late May. Due to the fact that copepods and rotifers did not attain their maxima at the same time, this spring pulse is irregular in appearance and extends over most of three months. Beginning in August the quantity of zooplankton increased gradually until it reached a peak in September. It will be noted that a

marked difference exists between the winter minimum of 3 per liter and the summer minimum of 23 per liter. A large portion of this summer zooplankton was composed of immature stages of copepods (Fig. 13). Many of the abrupt but temporary fluctuations appearing in the graph representing total zooplankton (Fig. 11) are due to sudden increases in quantity of a single genus or even species. Difference in size of spring and autumn pulses of 1939, is due primarily to greater abundance of protozoa during the latter period.

A complete understanding of the nature of seasonal variation of total zooplankton can be obtained only through knowledge of seasonal variation of the constituent plankters. The following section gives the salient features of predominant zooplankters and major zooplankton groups in respect to seasonal abundance. In some instances identification to species was not feasible; thus only genus is given. The list of zooplankters discussed consists of 52 forms, distributed among the major zooplankton groups as follows: Protozoa, 10; Rotifera, 21; Cladocera, 8; and Copepoda, 13.

PROTOZOA

Members of this group were relatively unimportant qualitatively and only during late summer and early autumn were they important quantitatively. Average number of Protozoa per liter for different times of the year was as follows: September to November, 1938, 8; November, 1938, to March, 1939, 0.0; March to August 25, 1939, 3; August 25, to September 25, 1939, 250. Average for the year was only 33 per liter.

Ceratium hirundinella (O. F. Müller) Schrank. Occurred only in autumn collections (Fig. 13).

Codonella cratera (Leidy). Occurred from June to September, 1939, with a maximum of 66 per liter.

Diffulgia lobostoma Leidy.

Diffulgia sp. This genus appeared irregularly throughout spring, summer, and autumn, especially during periods of violent water agitation. Following a stormy period it appeared in numbers of 400 per liter.

Epistylis sp. Occurred irregularly throughout summer months but did not exceed 10 per liter.

Holosticha sp. Appeared in collections of March, 1939, in numbers of 25 per liter.

Peridinium spp. Found during autumn of 1938, but did not exceed 3 per liter.

Trichophyra epistylidis Claparède and Lachmann. Occurred in the summer of 1939, in numbers not exceeding 8 per liter.

Vorticella sp. Present in most collections, usually attached to diatoms, but did not exceed 15 per liter.

Zoothamnium arbuscula Ehr. Found throughout summer months in quantities not exceeding 12 per liter.

ROTIFERA

Rotifers were present in all collections and ranked with copepods in abundance. Data on seasonal distribution of total Rotifera (Fig. 11)

show definite pulses during the autumn of 1938, and the spring and autumn of 1939. The autumn pulse of 1938 was irregular in nature and did not exceed a quantity of 45 per liter; the spring pulse reached a maximum of 75 per liter in May, 1939; and the autumn pulse of 1939, reached a peak of 250 per liter in late September. Average number of rotifers per liter during pulses and periods between pulses was as follows: September to November, 1938, 32; November, 1938, to April 18, 1939, 5; April 18, to June 5, 1939, 30; June 5, to August 11, 1939, 5; August 11, to September 25, 1939, 91.

Asplanchna herrickii de Guerne.

Asplanchna priodonta Gosse. This genus occurred in quantities not exceeding 4 per liter during spring and autumn.

Brachionus angularis Gosse. Appeared sporadically throughout the year but most abundant from July to September. Maximum number encountered was 17 per liter.

Chromogaster ovalis (Bergendal). Rare.

Collotheca mutabilis (Hudson). Occurred from July to October with a maximum of 18 per liter in August, 1939.

Colurella sp. Rare.

Conochilus unicornis Rousselet. Found in July and August collections with a maximum of 32 per liter.

Euchlanis sp. Found during spring, summer and autumn, in numbers not exceeding 3 per liter.

Filinia longiseta (Ehr.). Present from April to August but did not exceed 10 per liter.

Gastropus stylifer Imhof. Rare.

Keratella cochlearis (Gosse). Occurred in all collections but appeared in pulses only during the autumns of 1938 and 1939 (Fig. 12). It is one of the most abundant rotifers in this region, exhibiting a maximum of 150 per liter.

Keratella quadrata (Müller). Occurred in winter and spring collections but did not exceed 6 per liter.

Monostyla sp. Found in spring and summer, not exceeding 4 per liter.

Notholca longispina (Kellicott). Found in most collections and produced a pulse during April and May, 1939 (Fig. 12).

Notholca striata (Müller). Found only during March, 1939, in numbers not exceeding 6 per liter.

Ploesoma truncatum (Levander). Occurred in spring and summer collections, but did not exceed 4 per liter.

Polyarthra euryptera Wierzejski.

Polyarthra trigla Ehr. In counting no attempt was made to separate the species of *Polyarthra*. This genus showed a pulse each autumn during September and October and a small pulse during May and June, 1939 (Fig. 12).

Synchaeta sp.

Synchaeta stylata Wierzejski. In counting, no attempt was made to separate the two species of *Synchaeta*. This genus appeared in two pulses, one during April and May, 1939, with a maximum of 70 per liter, and a second during September, 1939, with a maximum of 40 per liter (Fig. 12).

Trichocera longiseta (Schrank). Found in spring collections but did not exceed 5 per liter.

Trichocera sp. (Diurella group). Rare.

CLADOCERA

Cladocerans were never abundant constituents of the plankton but they did show seasonal variation (Fig. 13). A pulse of cladocerans occurred from September to mid-December, 1938, with a maximum of 12 per liter, but from this time until May, 1939, they were apparently absent from the plankton. A spring pulse, with a maximum of 17 per liter, appeared in June, 1939; a summer pulse with a peak of 8 per liter occurred in August; and the autumn pulse with a maximum of 16 per liter appeared in September, 1939. Irregularity of the graph showing total Cladocera is due to the fact that the 8 species involved had their maxima occurring at different times. The average number of clado-cerans per liter during the two pulses was as follows: September to mid-December, 1938, 4.4; May 23, to September 25, 1939, 5.0.

Bosmina longirostris (O. F. Müller). Occurred in the plankton from September through December, 1938, with a maximum of 10 per liter. It appeared in quantities of 2 per liter in June, 1939, and again in August and September, 1939, with a maximum of 10 per liter (Fig. 13). The average number of this species during each autumn pulse was 3 per liter.

Ceriodaphnia reticulata (Jurine). Occurred during July and August, 1939, in numbers not exceeding 3 per liter.

Daphnia longispina (O. F. Müller). Occurred from September to December, 1938, with a maximum of 6 per liter and an average of 2 per liter. A pulse with a maximum of 9 per liter appeared in May and June, 1939, and from July to October, 1939, it was present in numbers not exceeding 3 per liter. The average number per liter from May to October was 3. This species was more abundant than any other cladoceran and had a seasonal distribution similar to that shown for total Cladocera (Fig. 13).

Daphnia pulex (de Geer). Found in quantities not exceeding 3 per liter during spring and summer.

Daphnia retrocurva Forbes. Occurred at about the same time as *D. longispina* but always in numbers less than 4 per liter.

Diaphanosoma leuchtenbergianum Fischer. Occurred from May through September, 1939, with a maximum of 3 per liter.

Leptodora kindtii (Focke). Found from May to September, never exceeding 1 per liter.

Sida crystallina (O. F. Müller). Rare.

COPEPODA

General characteristics of seasonal distribution of total copepods are shown in Figure 11. This group was most abundant during autumn and spring at which times pulses appeared. The pulse during the autumn of 1938 probably reached its peak in August before this investigation was begun, although there were 40 per liter present in early September. A spring pulse occurred from early April to mid-July, 1939, with a max-imum of 70 per liter in late June. In July the summer minimum of 20

per liter occurred but by August the number had increased to 40 per liter and this level was maintained to mid-September, 1939. It may be noted that the autumn pulse of 1938, and the spring pulse of 1939, were separated by a winter minimum of 2 per liter which existed from mid-December, 1938, to mid-April, 1939. This winter minimum is a sharp contrast, both in size and duration to the summer minimum which separated the spring and autumn pulses of 1939. Immature and adult stages of *Cyclops* and *Diaptomus* made up the bulk of copepod plankton and the following data on average number of these forms during pulses and between pulses will aid in visualizing the relative importance of these forms. Average number of adult *Cyclops* per liter from September through December, 1939, was 3; from January to May 23, 1939, 0.4; from May 23 to October, 1939, 11.0. Average number of *Diaptomus* per liter from September through December, 1938, was 5; from January to May 16, 1939, 0.7; from May 16 to September 25, 1939, 6.0. Average number of nauplii per liter from September to November 17, 1939, was 9; from November 17, 1938, to April 18, 1939, 1; from April 18 to September 25, 1939, 24. It will be seen from these data that nauplii were predominant at all times but especially so from May to October, 1939. Figure 13 shows the general features of seasonal variation of nauplii.

In the following discussion quantitative data are given for all species of copepods except *Diaptomus*. In many instances identification of female *Diaptomus* to species was not attempted; therefore, only general statements are made concerning the members of this genus.

Canthocamptus staphylinoides Pearse. Found in April and May in quantities of 1 per liter.

Cyclops americanus Marsh. Occurred from May to November but did not exceed 3 per liter.

Cyclops bicuspidatus Claus. Found throughout the year but most abundant in May and June, with a maximum of 7 per liter.

Cyclops brevispinosus Herrick. Occurred in most collections but was most abundant from April to September, with a maximum of 6 per liter.

Cyclops leucharti Claus. Occurred in most collections but most numerous from June to September, with a maximum of 6 per liter.

Cyclops prasinus Fischer. Found in collections from April to October, with a maximum of 4 per liter in August.

Diaptomus ashlandi Marsh. Occurred in most collections but was most abundant from May to September.

Diaptomus minutus Lilljeborg. Found from June to September.

Diaptomus oregonensis Lilljeborg. Occurred in most collections, but most numerous from April to September.

Diaptomus sicilis Forbes. Found in most collections but was most abundant in June.

Diapomus siciloides Lilljeborg. Present in collections from September to November, 1938, and during March and August, 1939.

Epischura lacustris Forbes. Occurred from April to October with a maximum of 8 per liter in August.

Limnocalanus macrurus Sars. Found in collections during the months of February and May, in quantities less than 1 per liter.

Per Cent Composition

Composition of individual plankton collections, made from September, 1938, to October, 1939, is shown graphically in Figure 10. In most instances Rotifera and Copepoda composed the greatest percentage of each collection and of these two, Copepoda was the most important component. Protozoa and Cladocera were of secondary importance and ranked about equal in respect to per cent composition. The following is a brief analysis of data pertaining to per cent composition of this plankton. (1) Protozoa in most cases did not constitute more than 20 per cent, usually less than 10 per cent, of total zooplankton from September, 1938, to September, 1939. However, during the month of September, 1939, this group composed from 50 to 70 per cent of the total zooplankton, due to a large pulse of *Ceratium*. (2) Cladocera composed from 10 to 38 per cent of the total zooplankton from early October to mid-December, 1938, but was relatively unimportant the rest of the year except for a few collections during June, July, and August, 1939. (3) Rotifers composed 30 to 85 per cent of the total zooplankton of all collections except those from late October to mid-December, 1938, and from late May to early August, 1939. This group was most important from late December, 1938, to May, 1939. (4) Copepods composed 40 to 60 per cent of the total zooplankton from late October through December, 1938, and 60 to 96 per cent of the zooplankton from late May to mid-August, 1939. Other times of the year this group composed less than 30 per cent of the total zooplankton. (5) Periods during which copepods composed significant percentages of the total zooplankton coincided with similar periods for Cladocera. Rotifers were most abundant in the plankton when Cladocera and Copepoda were least abundant.

Horizontal and Vertical Distribution

During this study little attention was given to the subject of horizontal distribution of zooplankton. The fact that the present data, based on weekly collections, yield rather consistent results in respect to seasonal trends of the zooplankton population indicates that horizontal distribution must be fairly uniform within the area studied. Wright and Tidd (1933) found that plankton Crustacea were not uniformly distributed in the "Island Section," but there was no evidence that they were consistently abundant at certain stations and consistently rare at others.

A limited amount of information pertaining to vertical distribution of zooplankton in the area studied is shown in Table XI. It may be noted that surface collections contained fewer zooplankters than collections from the other depths and the 5 meter-depth contained the largest number of plankters. Rotifera and Protozoa show a very irregular distribution, sometimes appearing in greater numbers at the surface, other times greater at one of the other depths. The Crustacea, however, show the normal distribution in that greater numbers occur at deeper levels during the day. Studies based on diurnal collections made at various times of the year are in progress and will furnish additional data on vertical distribution.

TABLE XI. Abundance of Zooplankton in Numbers per Liter

Depth in Meters	Group	Sept. 2 1938	Sept. 7	Sept. 16	Sept. 23	Sept. 28	Oct. 5	Oct. 12	Oct. 17	Oct. 28	Nov. 1	Nov. 5	Nov. 10	Nov. 17	Nov. 23	Dec. 5	Dec. 15	Dec. 19
0	Protozoa...	29.2	10.0	12.0	22.0	0.5	0.7	4.9	0.3	1.0	0.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0
	Rotifera...	29.3	35.0	45.0	44.0	26.5	8.9	7.8	46.9	4.7	2.9	0.6	5.2	8.9	4.0	2.2	1.9	1.1
	Cladocera...	0.5	2.0	8.0	1.0	1.3	1.0	0.7	1.1	6.3	3.0	7.9	0.9	2.1	1.6	0.2	0.5	0.0
	Copepoda..	31.6	37.0	26.0	19.0	26.0	6.5	7.4	1.8	7.2	5.4	9.8	6.1	7.8	5.8	4.5	1.8	0.9
	Total....	90.6	84.0	91.0	86.0	54.3	17.1	20.8	50.1	19.2	11.7	18.3	12.3	18.8	11.4	6.9	4.2	2.0
5	Protozoa...	40.0	20.0	15.0	2.0	0.6	1.1	2.0	1.2	0.5	0.8	0.0	0.0	0.1	0.1	0.0	0.0	0.0
	Rotifera...	46.0	36.0	39.0	53.0	63.8	15.7	6.9	27.7	4.2	3.8	1.4	4.8	12.1	5.5	4.1	4.8	3.2
	Cladocera..	3.8	5.0	8.0	3.0	4.9	4.1	5.3	21.5	6.5	16.3	6.4	8.2	4.8	3.0	1.0	0.5	0.9
	Copepoda..	46.0	38.0	29.0	21.0	36.6	13.7	10.8	16.4	10.2	12.2	9.4	11.5	12.3	9.8	5.7	2.0	1.6
	Total....	135.8	99.0	91.0	79.0	105.9	34.6	25.0	66.8	21.4	33.1	17.2	24.5	29.3	18.4	10.8	7.3	5.7
9	Protozoa...	25.0	16.0	12.0	2.0	1.5	1.9	2.0	0.8	1.0	0.1	0.0	0.3	0.0	0.0	0.0	0.1	0.0
	Rotifera...	30.0	50.0	45.0	40.0	38.2	19.2	8.1	10.3	3.5	4.1	3.3	3.9	7.7	5.6	5.3	2.0	3.5
	Cladocera..	2.6	7.0	5.0	3.0	2.5	3.5	2.7	9.9	7.5	3.8	7.7	4.5	2.1	10.1	3.9	1.3	0.6
	Copepoda..	37.0	56.0	39.0	18.0	19.6	15.7	10.6	8.4	18.6	9.6	16.9	10.7	10.9	11.7	7.4	4.0	2.0
	Total....	94.6	129.0	101.0	63.0	61.8	40.3	23.4	29.4	30.6	17.6	27.9	19.4	20.7	27.4	16.6	7.4	6.1

TABLE XI. (Continued)

Depth in Meters	Group	Jan. 10 1939	Jan. 23	Feb. 2	Feb. 11	Feb. 17	Feb. 25	Mar. 4	Mar. 10	Mar. 20	Mar. 29	Apr. 5	Apr. 11	Apr. 18	Apr. 25	May 3	May 9	May 16
0	Protozoa	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	25.0	0.3	0.0	0.3	0.5	0.5	1.5	0.4	5.9
	Rotifera	1.5	2.1	5.0	4.3	2.5	2.1	3.2	8.1	9.8	2.8	2.8	4.6	10.7	16.0	16.7	13.0	41.2
	Cladocera	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.3	0.0	0.0	0.2
	Copepoda	1.6	0.3	1.7	0.5	0.6	2.0	0.2	1.6	1.4	2.0	2.0	3.2	6.0	8.3	13.5	19.0	19.5
	Total	3.1	2.4	6.8	4.9	3.1	4.2	3.4	9.7	36.2	5.1	4.8	8.3	17.2	25.1	31.7	32.4	66.8
5	Protozoa	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	27.1	1.8	0.0	1.0	0.5	1.0	1.7	1.6	6.7
	Rotifera	1.8	4.4	3.2	6.1	5.1	3.2	3.7	10.7	5.7	5.3	4.8	6.5	13.3	16.9	33.0	20.8	51.9
	Cladocera	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.5
	Copepoda	1.0	2.8	2.2	3.2	2.3	1.9	2.3	1.3	1.1	3.2	3.1	1.3	8.0	14.2	29.1	40.0	41.9
	Total	2.9	7.3	5.4	9.4	7.4	5.2	6.0	12.0	33.9	10.3	8.0	8.8	21.8	32.1	63.9	62.4	101.0
9*	Protozoa		0.0	0.0		0.0	0.0	0.0	0.0	25.0	3.0	0.0	0.8	0.3	1.6	1.5	1.6	4.0
	Rotifera		3.4	3.6		4.9	2.6	1.1	9.5	6.9	4.0	3.2	7.6	14.8	26.5	26.2	30.5	34.2
	Cladocera		0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.1
	Copepoda		2.5	3.1		2.7	2.5	3.4	1.7	2.7	3.2	2.3	3.0	9.9	19.7	21.3	16.2	43.5
	Total		5.9	6.7		7.6	5.1	4.5	11.2	34.6	10.2	5.6	11.4	25.0	47.9	49.1	48.3	81.8

TABLE XI. (Continued)

Depth in Meters*	Group	May 23 1939	May 30	June 5	June 14	June 22	July 8	July 22	Aug. 1	Aug. 11	Aug. 25	Aug. 31	Sept. 6	Sept. 12	Sept. 19	Sept. 25
0	Protozoa	5.9	0.3	0.5	3.0	0.3	1.2	0.0	0.0	1.7	17.6	1.2	203.6	148.0	807.2	190.8
	Rotifera	52.9	15.8	3.5	3.8	0.9	4.9	0.4	0.3	18.6	22.6	29.2	114.2	87.4	244.0	205.2
	Cladocera	0.6	1.0	1.6	1.4	0.1	0.3	2.5	0.1	0.7	0.2	0.2	1.8	3.6	3.9	16.2
	Copepoda	25.4	46.8	42.0	45.8	15.9	10.3	47.6	0.7	43.7	19.0	31.0	67.8	24.0	30.4	22.8
	Total	84.8	63.9	47.6	54.0	17.2	16.7	50.5	1.1	64.7	59.4	61.6	387.4	263.0	1085.5	435.0
5	Protozoa	2.8	0.2	1.0	1.1	0.1	0.8	0.2	0.0	1.4	7.6	15.6	172.0	130.0	690.0	495.0
	Rotifera	125.9	13.2	2.4	1.1	0.5	27.8	32.0	4.9	25.3	39.8	30.8	54.2	89.2	237.6	135.2
	Cladocera	0.9	0.9	37.7	5.9	0.8	2.3	9.0	14.7	5.6	2.8	8.4	2.4	7.6	6.6	13.8
	Copepoda	104.2	52.1	56.0	36.7	39.3	32.9	52.4	92.7	69.9	40.6	42.2	29.8	44.4	33.0	39.6
	Total	233.8	66.4	97.1	44.8	40.7	63.8	93.6	112.3	102.2	90.8	97.0	258.4	271.2	967.2	683.6
9	Protozoa	2.0	0.4	1.0	0.4	0.0	0.3	0.0	0.0	1.3	6.0	9.2	67.6	96.0	980.0	453.0
	Rotifera	45.8	13.4	1.1	3.7	0.8	3.8	1.7	2.6	13.7	34.6	18.4	42.6	71.6	268.8	129.4
	Cladocera	0.4	5.6	8.2	4.6	0.0	4.4	5.3	7.8	6.1	2.0	4.0	4.8	6.4	6.6	15.0
	Copepoda	47.6	59.5	39.2	89.0	155.4	26.8	30.4	39.5	44.7	39.8	34.8	40.8	31.4	29.4	34.8
	Total	95.8	78.9	49.5	97.7	156.2	35.3	37.4	49.9	65.8	82.4	66.4	155.8	205.4	1284.8	632.2

DISCUSSION

Data presented in this paper, derived from a 14 months study of water in the Bass Islands Region of Lake Erie (Fig. 2) resemble in certain respects the data obtained from a general limnological survey of a much larger area, the "Island Section," conducted by the U. S. Bureau of Fisheries and the Ohio Department of Conservation during the spring, summer, and autumn of 1928, 1929, and 1930 (Wright and Tidd, 1933). This similarity suggests that weekly collections made in the Bass Islands Region may give information that is representative of a large portion of the western end of Lake Erie. The following discussion deals with the major features of the Bass Islands Region in respect to plankton and the environmental factors which influence it.

The shallow water of the Bass Islands Region, not exceeding 12 meters in depth, is kept in complete circulation throughout the year except during brief calm periods in spring and summer when conditions are favorable for thermal stratification. Only three times during the investigation was thermal stratification encountered and then it was only temporary in nature, producing little or no effect on the vertical distribution of chemical factors. It might be concluded that this part of Lake Erie resembles a sublittoral zone in respect to thermal and chemical conditions. The primary effect of the ice-cover which existed from January to April, 1939, was that of preventing violent churning of the water by wind. This resulted in lower turbidity even though the water was kept in complete circulation by currents. It is possible that during severe winters an extensive ice-cover may produce conditions different from those observed during the winter of 1938–39, but it appears that under most winter conditions water is kept in complete circulation. The fact that a phytoplankton pulse occurred under the ice-cover indicates that water conditions under the ice were not greatly different from those of the open lake.

Turbidity is believed to be one of the most important physical factors operating in the shallow waters of this area; however, present data do not justify conclusive statements. Examination of Figure 7 gives the impression that phytoplankton pulses occur at times of relatively low turbidity and small phytoplankton populations exist at times of high turbidity. Each phytoplankton pulse, autumn 1938, spring and autumn 1939, occurred when turbidity was relatively low, and periods between pulses were characterized by higher turbidity. Likewise, abrupt decreases and increases in quantity of this plankton during a pulse is seemingly related to fluctuations in turbidity, but a statistical treatment of these data does not yield a significant coefficient of correlation between turbidity and abundance of plankton. If turbidity does affect phytoplankton production it is likely that it is accomplished by influences antecedent to time of collection rather than on date of collection. Thus, it becomes necessary to make daily observations on turbidity and abundance of plankton during spring and autumn when the greatest fluctuations of both occur. Other investigators have reported data similar to that shown in Figure 7. Harris and Silvey (1940) in their work on Texas reservoir lakes found that maxima plankton productions occurred at times of low turbidity in Lake Worth

and Lake Bridgeport but in Lake Dallas and Eagle Mountain Lake maxima plankton productions occurred at times of high turbidity. Daily (1938) studied the phytoplankton of Lake Michigan in the vicinity of Evanston, Illinois, and states, "From weekly studies, it was difficult to ascertain the exact relation between turbidity and plankton pulses; however, the increases in turbidity appear to precede the plankton pulses." The writer believes that a positive correlation does exist between low turbidity and large phytoplankton pulses in this region but this subject awaits further investigation. If turbidity influences abundance of zooplankton it is probably accomplished indirectly through its effect on phytoplankton.

It is conceivable that large quantities of sediment in suspension could injure plankters through mechanical action or by carrying them to the bottom during settling. The writer (Chandler, 1937) observed such effects from studies of lake plankton entering a river. Another evident way by which turbidity can effect phytoplankton production is through reduction of the intensity of illumination at various depths, thus limiting the depth at which photosynthesis can occur. Examination of data on light penetration as determined by the Secchi disc and photometer (Tables III and IV) shows that light was often absent or greatly reduced below depths of 5 meters. Marked variations in depths to which light penetrated occurred daily as well as seasonally, as is indicated by daily turbidity readings (Table II and Fig. 7). The maximum depth to which light penetrated, according to photometer readings, was 9 meters during the summer of 1939, and the minimum was 0.3 meter in April, 1939. An average for the 14 months was 4.7 meters. It appears from these data that light conditions are such that phytoplankters at certain times are able to carry on photosynthesis at all levels from surface to bottom while at other times photosynthetic processes are limited to the upper meter of water. It must be kept in mind that the effect of light on abundance of phytoplankton is due to causes antecedent to time of collection and not at time of collection. High turbidity lasting several days would result in reduced photosynthesis in phytoplankters which would be reflected later in a reduced population. If this application be carried farther it is possible to understand how the degree of turbidity during spring, summer, and autumn might determine the time, duration, and size of phytoplankton pulses.

Unfortunately no information can be offered concerning the qualitative nature of light at various depths in the water of this region. It is known (Birge and Juday 1930, 1931) that turbid waters have a selective effect on transmission of spectral rays. Transmission of short-wave radiations is more affected by suspended materials than transmission of longer wave lengths. It becomes apparent that the effects of turbidity on plankton production can best be approached through a qualitative and quantitative study of light at various depths and the investigation of light requirements of individual plankters for photosynthesis.

Chemical data obtained in this investigation (Tables V-IX) show that chemical conditions vary with the season but differences in vertical distribution from surface to bottom were not significant for a given date.

There are no indications that chemical factors, dealt with in this paper, might have a limiting effect on plankton production. An investigation of dissolved inorganic elements in waters of this area has been carried on simultaneously with this plankton study, and there are indications that some of these elements may be limiting in effect. A discussion of the cycle of dissolved inorganic elements in the waters of this region and their influence on plankton populations will be the subject of another report.

Phytoplankton pulses occurred in the autumn of 1938, and spring and autumn of 1939; however, these three differed from each other in several respects and also from the pulses reported by Wright and Tidd (1933) in the "Island Section." The autumn pulse of 1938 occurred from early September to late October with a maximum of 330,000 units per liter appearing in late September (Fig. 7). This pulse was dominated by diatoms which constituted approximately 80 per cent of the total phytoplankton at this time. *Stephanodiscus* alone composed 75 per cent of the diatoms of this pulse but this form was nearly absent the following autumn. The autumn pulse of 1939 extended from mid-August to mid-October with a maximum of 320,000 units per liter occurring in late September. Diatoms were dominant during this pulse but in contrast to the previous autumn they never composed more than 60 per cent of the total phytoplankton and often less than 50 per cent. Chlorophyceae and especially Myxophyceae contributed much more heavily to this pulse than that of the previous autumn. Turbidity and depth of light penetration (Fig. 7 and Table IV) were very similar during the autumns of 1938 and 1939, especially at the time of phytoplankton pulses, but antecedent to the pulses these factors were different for the two autumns. Average depth to which light penetrated during July and August, 1938, based on four photometer readings, was 3.0 meters while for the same period during 1939 it was 8.0 meters. It would appear that more favorable light conditions of the second year resulted in larger quantities of greens and blue-greens but fewer diatoms. It is quite possible that the different algal forms have different light requirements and that turbidity and depth of light penetration just preceding the pulse influence the abundance of the various groups during the pulse.

The spring pulse of 1939 occurred from late February to early April with a maximum of 247,000 units per liter occurring in late March. Diatoms composed about 90 per cent of this plankton but no one genus was dominant since *Asterionella*, *Fragilaria*, *Synedra*, and *Tabellaria* contributed heavily to this pulse. This entire pulse occurred while an ice-cover was present. Apparently the ice-cover had very little effect on water conditions as reflected by plankton, temperature, and chemical data. Mild winter conditions resulted in a restricted ice-cover limited to the Bass Islands Region, with open water on all sides. This restricted ice field formed a bridge between islands, underneath which the water circulated freely and no doubt mixed with water of the open lake. It might be expected that an ice-cover would reduce turbidity of the water through protection from wind action but during 1939 the water was more turbid during winter than summer. Apparently the turbid water of the open lake mixed to some extent with the ice-covered water. Possibly

the conditions of this particular winter are not typical of winters in general but this study does furnish some interesting data that may be of considerable value when compared with data from other winters. Temperature records during this pulse indicate little change from that of the previous two months and suggest that temperature in itself has little influence on the periodicity of diatoms. Wright and Tidd (1933) reported that the maxima of the spring pulses of 1929 and 1930 occurred in late May and early June. If water temperatures of those years were at all similar to those of a corresponding time in 1939, the plankton pulse must have occurred when the water was 17.0° C. which is 16 degrees higher than when the spring pulse of 1939 occurred.

Wright and Tidd (1933) state that the average abundance of phytoplankton groups, in thousands of units per liter, for the period late May to early October of 1929 and 1930 was as follows: diatoms, 90; greens, 38; blue-greens, 58. Similar data obtained in 1939 for the same period are as follows: diatoms, 76; greens, 20; blue-greens, 63. It is evident that diatoms and greens were more abundant in 1929 and 1930 than for the same period in 1939, while the blue-greens were less abundant. Since the spring pulse of 1939 occurred much earlier than it did in 1929 and 1930 the above data probably are not comparable. To make them comparable the spring pulse of 1939 should be included in the averages. When this is done the average for the diatoms becomes 123 instead of 76, but the other groups are affected very little. It appears from these data that the quality and quantity of phytoplankton in 1929, 1930, and 1939 were quite similar for comparable periods, even though the pulses did not occur at corresponding times.

Zooplankton pulses occurred during the following periods: September to November, 1938; April to July, 1939; and August to October, 1939. No one plankton group dominated all three pulses as is indicated by the following: autumn of 1938, Copepoda and Rotifera contributed about equally; spring of 1939, Rotifera and Copepoda were equally important during the first part of the period while Copepoda was predominant in the latter part; autumn of 1939, Protozoa was dominant. It is apparent that composition of this plankton varies from season to season for the same year and likewise it varies from year to year for corresponding seasons. Phytoplankton and zooplankton pulses appeared at approximately the same time in the autumns of 1938 and 1939, but the phytoplankton pulse, during the spring of 1939, preceded the zooplankton pulse by 6 weeks; however, a secondary phytoplankton pulse occurred along with this zooplankton pulse. Dependence of zooplankton pulses upon phytoplankton pulses is problematical but the two usually occur at about the same time rather than being widely separated as reported here. The spring phytoplankton pulse of 1939 appeared several weeks earlier than it did during the springs of 1929 and 1930; however, the zooplankton pulses for the three years occurred at about the same time (May-June).

A comparison of certain zooplankton data based on a survey of the "Island Section" of Lake Erie (Wright and Tidd, 1933) with that of the present investigation reveals some interesting facts. Wright and Tidd state, "Nothing is known definitely regarding abundance in the months

of December, January, February and March, but there are reasons for believing that crustacea are rare during that period. During the remaining months, the adult crustacea were rare in spring and autumn and were most abundant in summer. In 1930 copepod larvae were most abundant in late spring and probably the same was true in 1929." Data from the Bass Islands Region show that during December, January, February, and March the average number of adult plankton crustacea was 2.0 per liter, which confirms the above statement. However, in this region adult plankton crustacea were most abundant in May and June, and September, while the summer population, though rather large, was smaller than the above periods (Fig. 13). Nauplii were slightly more abundant in spring than in autumn but an almost uniform number with a mean count of 24.0 per liter existed from late April to October, 1939.

The four most abundant genera of plankton Crustacea in the "Island Section" were *Cyclops, Diaptomus, Daphnia,* and *Diaphanosoma,* and the mean count per liter for each during the period late May to early October, for the years 1929 and 1930, was as follows: *Cyclops,* 10; *Diaptomus,* 6; *Daphnia,* 4; and *Diaphanosoma,* 1. Mean counts of these same genera based on data from the Bass Islands Region for a corresponding period in 1939 are as follows: *Cyclops,* 11; *Diaptomus,* 6; *Daphnia,* 3; and *Diaphanosoma,* 0.5. There is a marked similarity between these two sets of data which suggests that plankton data derived from the Bass Islands Region are representative of the entire "Island Section."

Practically no data on Protozoa and Rotifera were presented in the summary report of the investigation of the "Island Section" by Wright and Tidd, but these groups were found to be numerically important in the plankton of the Bass Islands Region. Rotifera ranked next to Copepoda in per cent composition of total zooplankton, and during winter months it constituted a greater percentage of total zooplankton than any other group. It is quite possible that Wright and Tidd used a coarser meshed net for zooplankton collections than was used during the present investigation, thus allowing many Protozoa and Rotifera to escape. From the standpoint of fish food, Rotifera and Protozoa are relatively unimportant in comparison with Cladocera and Copepoda, but nevertheless these groups must be considered as important constituents of the plankton.

<div align="center">SUMMARY</div>

1. Year-round limnological data based on weekly collections in the region of the Bass Islands, Lake Erie, are presented. Emphasis is placed on seasonal variation of centrifuged phytoplankton, net zooplankton, and certain physical and chemical conditions characteristic of the region.

2. Water, with a maximum depth of 12 meters in this region, circulates from surface to bottom throughout most of the year, due to currents and wind action. This results in

nearly uniform vertical distribution of chemical factors, temperature, turbidity, and phytoplankton.

3. From late December, 1938, to late March, 1939, an ice-cover existed, through which winter collections were made. The ice-cover being confined to this island region apparently formed a bridge between islands, allowing water beneath it to mix freely with water of the open lake.

4. Turbidity is believed to be one of the most important physical factors influencing the productivity of the water in this region. It varied from 3 to 140 p.p.m. and was greatest at times of low plankton production and lowest at times of high plankton production.

5. Maximum depth to which total light penetrated into water varied from 0.3 meter in April to 9 meters during July and August; average for the year was 4.7 meters.

6. Data in this paper suggest that turbidity influences the quality and quantity of light available at various depths for photosynthesis, which in turn may influence the time, duration, and size of phytoplankton pulses.

7. Definite phytoplankton pulses occurred as follows: early September to late October, 1938, with a maximum of 330,000 units per liter; late February to early April, 1939, with a maximum of 247,000 units per liter; mid-August to mid-October, 1939, with a maximum of 320,000 units per liter.

8. Diatoms constituted from 50 to 100 per cent of total phytoplankton except during summer months.

9. Chlorophyceae and Myxophyceae together composed 50 to 90 per cent of the total phytoplankton during June, July, and early August.

10. Composition of phytoplankton differed considerably in the two autumns. In 1938, diatoms constituted from 70 to 90 per cent of the total, while Myxophyceae and Chlorophyceae together composed only 10 to 30 per cent; in 1939, diatoms composed 25 to 55 per cent while Myxophyceae and Chlorophyceae together constituted from 45 to 75 per cent of the total.

11. A phytoplankton pulse with a maximum of 247,000 units per liter occurred under the ice-cover during March, 1939.

12. Zooplankton pulses occurred as follows: September to November, 1938; April to July, 1939; August to October, 1939.

13. Rotifera and Copepoda, about equal in abundance, together composed 40 to 95 per cent of the total zooplankton from September, 1938, to September, 1939. During September, 1939, Protozoa constituted 48 to 72 per cent of the total.

14. Zooplankton and phytoplankton pulses of the two autumns coincided, but the spring phytoplankton pulse terminated before the zooplankton pulse began; a difference of 10 weeks existed between maxima of the two pulses.

15. Physical, chemical, and plankton data of this study resemble in many respects similar data derived from a study of a large portion of the western end of Lake Erie, by Wright and Tidd in spring, summer, and autumn of 1929 and 1930. This suggests that weekly collections in the region of the Bass Islands may supply data that are representative of a large portion of the western end of Lake Erie.

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TOTAL DISTRIBUTION OF TASTE BUDS ON
THE TONGUE OF THE PUP[1]

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INTRODUCTION

This paper reports the results of the second of a series of proposed studies from this laboratory on the distribution and innervation of taste buds; the first having been published by Elliott ('37).

A search of the available literature indicated that information on taste buds was limited. As Elliott ('37) has given a brief review of the literature, reference to previous research will be considered in a comparative way in the portion of this paper devoted to the discussion of the present investigation.

I wish to express my appreciation to Dr. Rush Elliott, who directed the problem, for his initial suggestion of this research and for the timely suggestions given during the course of the investigation which saved needless loss of time and waste of material; to Dr. F. H. Krecker for use of laboratory material and equipment; and to Mr. Lawrence Goldberg for the photographic work appearing in this paper.

MATERIALS AND METHODS

The material for this study consists of tongues taken from six pups which varied in age from one to five days. Three of these tongues which were used in the histological work were from five-day old pups of the same litter. These tongues were fixed in 10% formalin for ten days and washed in running water for twenty-four hours. The tongues were dehydrated in a graduated series of ethyl alcohol to 70%.

One tongue was dehydrated and infiltrated by the dioxan method as outlined by Guyer ('36). Difficulty due to hardening was encountered in sectioning the tongue dehydrated by this method. The other two tongues were dehydrated and infiltrated by a modification of the normal butyl alcohol technique described by Lee ('37). These three tongues were sectioned serially at 20 micra. Mallory's triple stain and iron hematoxylin were tried, but a dilute solution of Delafield's hematoxylin proved most satisfactory and was used for nearly all of the sections. Euparal was used for the mounting medium.

By a careful study of several taste buds it was found that all buds appeared in two sections and some appeared in three sections; it seems

from this that a bud must be nearly forty micra in thickness. A figure to show the total distribution of the taste buds over the dorsum of the tongue was prepared by dividing the tongue into twenty-six divisions. The reasons for using this number of divisions were that the circumvallate papillae of all tongues fell into comparable areas, and the average number of sections in each division was a whole number. A record of the number of taste buds exclusive of the circumvallate papillae was made and a table prepared (Table I) to show the localization in each region.

TABLE I

TABLE OF NUMBER OF TASTE BUDS FOUND IN THE FUNGIFORM PAPILLAE OF THE THREE TONGUES STUDIED

DIVISION	TONGUE 1	TONGUE 2	TONGUE 3	AVERAGE ALL TONGUES
1	13	18	16	16
2	42	33	57	44
3	65	44	81	63
4	62	52	94	69
5	75	34	89	66
6	83	27	91	67
7	80	51	101	77
8	91	33	101	75
9	117	49	89	85
10	90	49	84	74
11	101	58	87	82
12	51	59	77	62
13	53	48	86	62
14	60	70	91	74
15	49	85	93	76
16	66	83	90	80
17	84	101	97	94
18	79	115	89	94
19	84	79	112	92
20	53	42	99	65
21	8	7	44	20
22	10	6	6	7
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
Total...	1,416	1,143	·1,774	1,444

Each section is 20 micra in thickness. Each division in tongue number 1 represents 76 sections; in tongue number 2, 68 sections; in tongue number 3, 75 sections; average for all tongues, 73 sections.

It was noted that the number and the positions of the circumvallate papillae were not constant in the tongues prepared for histological study. Three more tongues were studied under the macroscopic camera lucida and the positions of the circumvallate papillae plotted. In figure 2 the positions of these papillae in the three tongues used in the histological study are represented by the figures in the top row; the lower row of figures are of those tongues which were used in the macroscopic study only.

Counts of taste buds present in the circumvallate papillae of tongue number 2 were made by use of serial projection photographs at a magnification of 200 diameters.

An outline of a tongue was prepared by projection, measurements being made of every seventy-fifth section of tongue number 3. By use of this outline a figure (Fig. 4) was prepared to show the total distribution of taste buds over the entire dorsum of the tongue. This number was reckoned by taking the average number of taste buds appearing in the fungiform papillae of the three tongues and the total number of taste buds observed in the circumvallate papillae of tongue number 2.
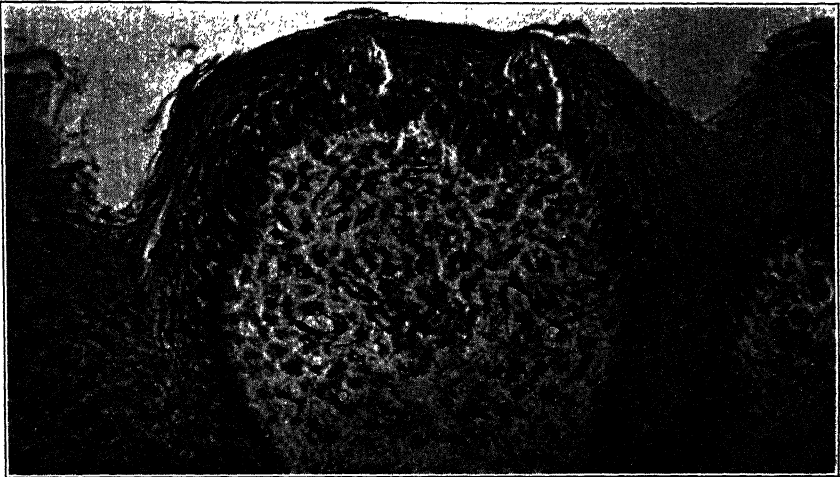
Fig. 1. Photomicrograph of a normal fungiform papilla with two taste buds in its top. × 350.

DISCUSSION

Taste buds are described in textbooks of histology (Bailey, Bremer, Maximow and Bloom, and Piersol) as occurring on various parts of the tongue, on the glossopalatine arch, on both sides of the epiglottis, on the posterior wall of the pharynx down to the inferior edge of the cricoid cartilage, on the soft palate especially in the region of the uvula (Hoffman, 1875), and in the region of the palatine tonsil of the foetus (Ponzo, '07). This paper is restricted to a study of the total distribution of taste buds on the tongue.

On the dorsum of the tongue of the pup, filiform, fungiform, and circumvallate papillae were found. Considerable variation in size and shape was noted in all three types of papillae. Fungiform papillae varied from a type which resembled a filiform papilla to one which was similar to a circumvallate papilla with no moat surrounding it. They were tallest near the edges of the tongue. The fungiform papillae were found to vary in thickness from 0.2 mm. to 0.32 mm.; most of them being 0.2 mm. in diameter. This type of papilla in its typical form was found to be limited to the area of the tongue anterior to the circumvallate papillae. In the caudal region of the tongue, the circumvallate papillae were found in a "V" formation with the apex of the "V" directed caudad, as they are described by numerous histologists. They varied in diameter from 0.24 mm. to 0.62 mm. There seems to be a

great difference in size between these papillae and similar papillae of the human, for Bremer ('36) described the adult human papillae to be from 1 mm. to 3 mm. in diameter.

The taste bud of the pup was found to be an ellipsoidal shaped body with a diameter of 40 micra and a longitudinal axis of 60 micra. The taste bud in the right side of the top of the fungiform papilla illustrated in Figure 1 shows cellular relationships of the taste bud. The large peripheral lightly stained cells are the supporting cells of the bud, and the long inner darkly stained ones are the gustatory cells. The outer and inner taste pores are both distinguishable.
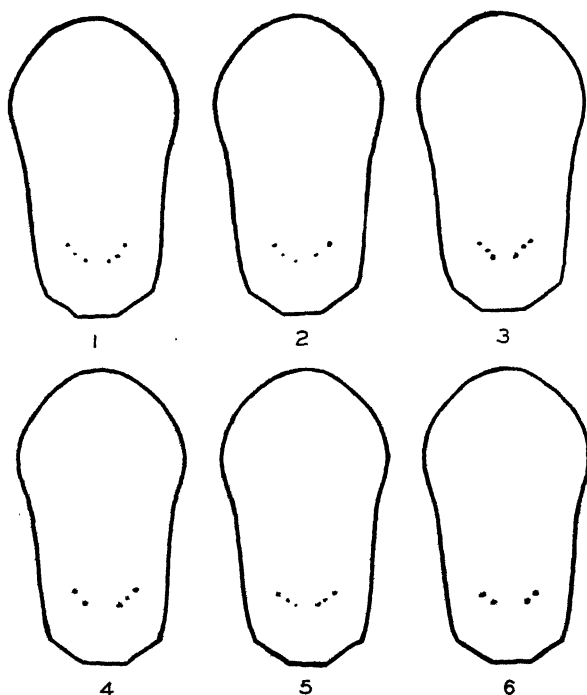
Fig. 2. Outline figures of six tongues to show uneven number and distribution of the circumvallate papillae. Figures 1 to 3 inclusive represent the tongues used in the histological study. Figures 4 to 6 inclusive represent the tongues used in the macroscopic study. (Actual size.)

In the pup, the taste buds of the tongue were found to be limited to its dorsal surface. In this area they were found only in the fungiform and circumvallate papillae. This was in agreement with the condition observed in the kitten by Elliott ('37), but it is contradictory to the location of taste buds in the child at birth as described by Bremer ('36) who states that in addition to buds being found in the two types of papillae just mentioned that they are also present in some of the filiform papillae. Schumacher ('27) describes fungiform papillae as appearing over the entire dorsum of the tongue and always possessing taste buds regardless of where they are located. The findings on the pup's tongue

are contradictory to this, for buds are found in these papillae only when they are located anterior to the circumvallate papillae.

The location of taste buds in the fungiform papillae have been described by various histologists as being present in the sides of these papillae; Elliott ('37) described them as having buds present in both the sides and tops. In this investigation buds were found to be present only in the tops of the fungiform papillae (Fig. 1). Olmsted ('21) gave four as the average number for buds present in this type of papilla of the dog. In his work on the kitten, Elliott ('37) found four to be the maximum number of buds present in any papilla. In the pup's tongue six was the maximum number of buds observed in a single papilla. This papilla was large and was located near the midline about midway between the tip of the tongue and the circumvallate papillae. In the

Fig. 3. Photomicrograph of a circumvallate papilla with two taste buds appearing in the floor of the trench. × 135.

present study, three was the average number of buds found in a papilla of this type.

Taste buds are described as being quite numerous in the infant by Schumacher ('27) and Arey et al ('35). The last mentioned investigators described the taste buds as occurring in patches. The results of the present study confirmed both of these points. In Table I is tabulated the number of taste buds exclusive of those found in the circumvallate papilla, found on all of the tongues used in the histological study. The total average number of the buds observed was found to be 1444 with a variation from the average of approximately 330 buds.

During the histological study of the tongue, it was noted that the circumvallate papillae were not constant either in number or in position. A study was made of the number present and their exact location plotted, as mentioned previously. The number present was found to

vary from four to six. These papillae were not in symmetrical arrange-
ment, as shown by figure 2, for in tongue number 2, for example, four
papillae were found to be present on the left side while only two were
present on the right side. No median papilla was observed in any of
the six tongues. This was held to prove further that no symmetrical
arrangement existed, for when five papillae were present, as in tongue
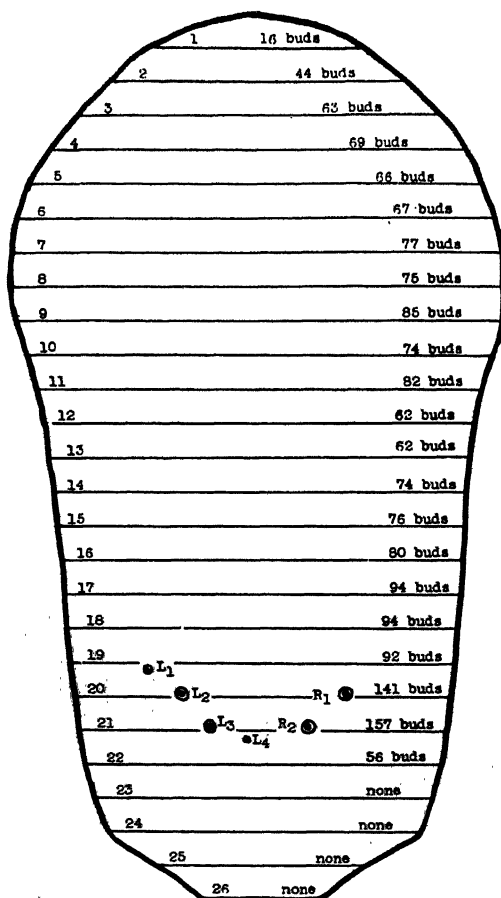
Fig. 4. Graphic representation of the average total regional distribution of
taste buds over the entire dorsum of the three tongues studied for number of buds
in fungiform papillae and for tongue number 2 studied for number of buds in cir-
cumvallate papillae. Each area represents seventy-three sections of a 20 micra
tongue thickness. The positions of the circumvallate papillae in tongue number 2
are plotted. × 3.

number 4, three were found on the right half and two on the left half of
the tongue.
    The presence of this variation seems to be in agreement with the
condition as described by Bailey ('21) for the human in which he stated
that the circumvallate papillae in man varied from nine to fifteen in

number, but it is not in agreement with the arrangement of these papillae as described by Elliott ('37) in the kitten, for two circumvallate papillae were found in a single median trench, nor does it agree with the condition observed in the monkey by Vastarini-Cresi ('15), in which he found that a median circumvallate was present on the tongue of this mammal.

The region of the circumvallate papilla has been described by various histologists as the area of the tongue which possesses the keenest sense of taste. Addison ('26) estimated that 100 to 150 was the maximum number of taste buds present in a single circumvallate papilla of the human. Arey et al ('35) found that the number present varied with the age of the individual. They gave 788 buds for the papilla and 231 buds for the outer trench wall as the highest number observed in their work.

In this investigation, a count was made of the buds which were found in the circumvallate papillae of tongue number 2. Seventy was the greatest number of buds observed in any one papilla, these being found in papilla L_2, Figure 4; of these twenty-six were found in the top of the papilla and forty-four in the sides. The total number of buds observed in the circumvallate papillae of this tongue was two hundred sixty-two, of which one hundred twenty-one occurred in the tops, one hundred thirty-nine in the sides. Two buds were observed in the floor of the trench encircling circumvallate papilla L_3 of tongue 2 (Fig. 3). This last condition was described as rare but present in the human by Arey et al ('35). Probably the reason for the presence of a lower number in the pups than in the human is traceable to the difference in size of the papillae of these mammals, as previously mentioned. Taste buds are described as appearing in the outer wall of the trench in the human by Bailey ('21) and Arey et al ('35). None were observed in this position in the pup.

The author was interested in the shift of the acuity for lingual taste toward the region of the circumvallate papillae, as pointed out by Stahr ('01) in his work on the human and confirmed by Elliott ('37) for the case of the kitten; so, Figure 4 was prepared to obtain a more complete picture of the total number of taste buds of the different areas of the tongue. It can be noted that 1706 buds represents the average number present per tongue in this study. An area near the tip is quite well supplied with taste buds; this was mentioned for the dog by Olmsted ('21). There seems to be a slight shift in the keenness of the sense of taste toward the region of the circumvallate papillae where it would seem to be keenest by virtue of the great number of taste buds present.

CONCLUSIONS

1. In the pup all of the taste buds which are observed on the tongue are limited to the dorsal surface where they are found only in the fungiform and circumvallate papillae.

2. An average of 1706 buds per tongue was observed (Fig. 4). This average number is composed of 262 buds observed in the circumvallate papillae (of tongue number 2) and 1444 buds, the latter number being the total average number found in

the fungiform papillae of the three tongues used in this study. The total regional distribution of the buds in the fungiform papillae of all tongues studied is shown in Table I.

3. The taste buds found in connection with fungiform papillae were observed to be present only in the tops of such papillae. The greatest number of taste buds which was observed to occur in any fungiform papilla was six.

4. There is a very gradual increase in the number of taste buds from the tip of the tongue toward the circumvallate papillae. No taste buds were found caudad of the region of the circumvallate papillae (Fig. 4).

5. The circumvallate papillae were found to vary in number from four to six and this region contains the greatest number of taste buds (Fig. 4).

6. The taste buds observed in connection with the circumvallate papillae were found in the tops and sides and in the floor of the trench which surrounded the papillae (Fig. 3). Buds were found to be most numerous in the sides of such papillae.

7. In the adult human, taste buds are described as being present in the outer, trench wall (Arey et al '35). No buds were found in this position on the tongue of the pup.

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ON THE BIOLOGY OF DROSOPHILA IMMIGRANS STURTEVANT WITH SPECIAL REFERENCE TO THE GENETIC STRUCTURE OF POPULATIONS[1]

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TAXONOMY

The species which forms the subject of this account was first identified by Sturtevant (1918) as *Drosophila tripunctata* Loew. After re-examination of type material he described it as a new species, *Drosophila immigrans* (Sturtevant, 1921). Duda (1924) splits the Drosophila into a number of subgenera and places this species in the subgenus Spinulophila, subgen. n. He separates Drosophila s. str. from Spinulophila on the basis of a row of short, black bristles on the inner aspect of the first femur in the latter. Sturtevant (1939) in a recent careful study based on the comparison of many species of Drosophila in respect to a large series of external and internal characters has considered a number of Duda's subgenera to be invalid. He proposes dividing the genus into three subgenera. On this basis *D. immigrans* falls into the Drosophila s. str.

We include here the taxonomic description taken from Sturtevant's (1921) monograph on the North American species of Drosophila.

Male.—Arista with about six branches above and three below. Antennae yellow. Front over one-third width of head, wider above, yellow; ocellar dot dark brown. Second orbital one-fourth size of other two. Second oral bristle over one-half length of first. Carina broad, flat; face yellow. Proboscis yellow. Cheeks yellow; their greatest width about one-third greatest diameter of eyes. Eyes with rather thick pile.

Acrostichal hairs in eight rows; no prescutellars. Mesonotum and scutellum dull brownish-yellow. Pleurae and legs pale yellow. Apical and preapical bristles on first and second tibiae, preapicals on third. A row of very short, stout bristles on lower apical part of first femur. Basal joint of first tarsus about half as long as corresponding joint of middle leg, and thicker. Second tarsal joint of first leg also somewhat thickened and shortened.

Abdomen dull yellow, each of the four basal segments with an interrupted posterior black band. The band on the fourth segment is sometimes entire. Fifth segment black.

A single bristle at tip of first costal section (before distal break). Wings clouded at tips of first and second veins and on posterior cross-vein. Costal index about 4.4; fourth-vein index about 1.2; 5x index about 1.0; 4c index about 0.5.

Length body 2.5 mm.; wing 2.7 mm.

Female.—Same as above, except basal tarsal joint of first leg about two-thirds as long as corresponding joint of second leg, not thicker. Second joint of tarsus of first leg not shortened or thickened.

GEOGRAPHICAL DISTRIBUTION AND ECOLOGY

Sturtevant (1921) gives many collection records from widely separated regions of the United States and from Costa Rica, Norway, Australia, and the Hawaiian Islands. The same author (Sturtevant, 1927) lists specimens from Formosa and India, and describes a new variety, *immigrans formosana*. Duda (1924) records it from Europe and Formosa, and Kikkawa and Peng (1939) from Japan. Sturtevant comments on its rarity in early collections, the first American specimens being taken in 1913. He thinks that it may be of Pacific origin. The presence of several closely similar forms in the Philippines and other parts of the Far East lends weight to this view. Today the species is very common throughout the United States. I have taken it in Massachusetts, New York, New Jersey, Pennsylvania, Tennessee, Ohio, Missouri, and California. It represents a highly successful introduced form in many sections and local communities of the United States.

Drosophila immigrans is more tolerant of low temperatures than a number of tropical species which form large summer populations in the northern part of the United States. *Drosophila hydei, melanogaster* and *simulans* are always completely killed off outdoors in this latitude, and overwinter only in buildings. Immigrans, on the contrary, is capable of surviving the milder winters outdoors, but is killed off by a severe season. This fact has been well established for northern Ohio through collections made over a period of years by Harrison Stalker and the author. In some years immigrans is rare or absent from fairly extensive spring collections, but even in these years it can be taken in abundance in the autumn. In other years, the summer of 1939 for example, following a mild winter immigrans appeared in numbers in collections of early summer from woods as well as in town.

It appears that *Drosophila immigrans* can breed in the woods, possibly on the same type of food as robusta, affinis, and

other non-fungus feeding woods species. However, it would seem to be more successful in town, breeding on over-ripe fruit, garbage, etc. Following a cold winter the few individuals which over-winter indoors give rise to a small spring population which gradually spreads, building up where food, temperature, and humidity are favorable and in many cases reaching woodland territory. If the following winter is mild flies over-winter in the woods, probably among leaves, under logs and rotting stumps, and in similar sheltered spots. These flies are then ready to build up a large spring population which will be represented in early summer collections from these localities. I have placed cultures of *Drosophila immigrans* outdoors in the autumn under air temperatures considerably below freezing, and have found that some of the flies survive after a two-day exposure.

Drosophila immigrans has a rapid life cycle, fourteen days from egg to egg under optimum conditions. These conditions are probably seldom reached under natural environments, particularly on account of the fall in night temperature even in summer to a point below that at which larvae grow most rapidly. However, this species has the shortest life cycle of the larger Drosophila. This fact, coupled with a high fecundity under favorable conditions, makes possible the building up of large populations within a short time in a given locality. Where seasonal fluctuations in temperature and moisture are limiting factors, a few days difference in length of life cycle has an important bearing on the flaring out of populations from small foci, the time at which an approximate breeding equilibrium may be reached, and the degree of homogeniety of local colonies which have bred up to a point where all available food is being used.

Drosophila immigrans, breeding in the northern United States, is a species which in mild years is likely to form spring and early summer populations large in area but low in density, breeding in the woods as well as in towns, on food similar to that used by typical native woods species. The dense localized populations developing later in the summer on accumulations of refuse, decaying fruit, etc., are likely to have sprung from migrants working in from many surrounding sources. In contrast, after a hard winter there will be no widespread spring and early summer populations and the dense aggregates formed in late summer and early autumn will be more spotty in distribution and homogeneous in structure, due to their development

from small localized foci of flies over-wintering indoors or in particularly favorable locations for winter survival. The migration out into woodland territory in such a season will progress into the autmun providing the proper humidity conditions are present.

A study of Drosophila populations breeding on a large citrus dump near Azusa, Southern California, and on a refuse heap from a canning factory and fruit and grocery wholesaler near Wooster, Ohio, has given some data on the breeding habits of the species present. In both places *Drosophila hydei* is the dominant form. Immigrans, melanogaster, simulans, and buskii are found in smaller numbers. Others also occur but in still less abundance. In both situations almost pure stands of hydei in all stages of development may be found in many parts of the breeding ground. However, small areas may be found where immigrans or melanogaster predominate in collections of larvae, pupae, and adults. An explanation of this localized concentration of minorities in a habitat where one species is vastly in the majority depends on a knowledge of such factors as breeding habits, micro-environments, and the actual sequence of events necessary to ensure the inception and continued development of a given generation of a species. Actually, both in California and Ohio the flies seek shelter from the direct rays of the hot, mid-day sun. Then in late afternoon they come out and feed voraciously in spots where the humidity is high and the food supply abundant and of the right quality. This occurs at relatively high temperatures. As the temperature continues to drop in the late afternoon courting and copulation occur. At a still lower temperature oviposition takes place in humid areas which are likely to be protected from rapid drying. A favorite place for egg-laying is a crevice in relatively fresh food. There is often some desultory inter-specific courting, but the tendency is for groups of one species to congregate in a limited area. This is followed by intra-specific courting and copulation. It seems likely, although the observation has not been made, that the females remain close to the point of copulation and deposit their eggs in the immediate vicinity later in the evening. The output from a few dozen females would be sufficient to account for these small local populations of a minority species observed here and there in the general habitat. Whether there is some local favorable stimulus which draws a minority species together at a given point I have been unable to determine. It may only

be that the mutual attraction of individuals of a given species tends to form concentrated local groups at copulation and egg-laying time. One gets the impression that both immigrans and melanogaster populations are breeding on fresher food than hydei (Spencer, 1932)

There is no doubt but that adults, pupae, and larvae of immigrans as well as other species are capable of withstanding much higher temperatures outdoors than in bottle culture without sterilization or injury. This seems in large part due to the removal of deleterious gases as carbon dioxide under the better ventilation of the natural environment. Furthermore, rapid evaporation from surfaces exposed to air of low or medium humidity undoubtedly lowers the temperature in the micro-environment of the air film of a couple of millimeters thickness to which the fly is actually exposed when resting on the surface in question.

PHYSIOLOGY

A number of facts of interest concerning the life cycle and physiology of this fly have been observed, some of which have an important bearing upon its adaptability as a form for genetic study. As stated above, the life cycle under optimum conditions is fourteen days. This may be divided into egg, larval, pupal, and adult periods. The eggs are much smaller than in most Drosophila species, have four tapering filaments, and are buried deeply in the food medium when this consists of corn-meal or banana agar. They require approximately thirty hours to hatch at 24 C. Both larvae and adults are very sensitive to acidity and excess carbon dioxide formation in vial or bottle cultures. For this reason high temperatures should be avoided where fermentation is likely to occur, as in cultures where yeast is being grown. Immigrans larvae grow quite well on Fleisch-mann's yeast suspension, using "kleenex" tissue as a base. Flies from larvae grown on this medium are large and vigorous. Where yeast suspension is used for the larvae, adults may be fed on corn-meal molasses agar with a minimum of yeast. The use of "moldex" has made the culture of immigrans much easier, as this ingredient in the medium cuts down bacterial, mold, and yeast growth to a point where there is little danger of adult flies being injured by carbon dioxide formation at temperatures below 25 C.

Immigrans is similar to hydei and melanica and unlike virilis and funebris in requiring re-culturing for each new generation. It is not safe to add fresh food to old culture bottles of immigrans as the whole culture is likely to deteriorate from bacterial growths. With funebris or virilis the addition of fresh food to old cultures keeps them running indefinitely. The difference in species in regard to the length of time they may be kept without re-culturing seems to depend on the ability of their larvae to utilize old, worked-over media, and the tendency for certain species to be associated with bacterial growths which prove deleterious.

The species is intermediate in activity between such active forms as melanogaster, simulans, hydei, and repleta and sluggish types as funebris and robusta. It etherizes slightly faster than melanogaster and slower than robusta, which places it about the center of the range of etherization-time of the species of Drosophila investigated. It has the habit of defecating as it goes under ether. This is likely to prove inconvenient for the investigator where large numbers of immigrans are being etherized. To keep the flies clean it is advisable to use a large etherizer or to handle fewer flies at a time.

Of all the species studied the males of immigrans become sexually mature the earliest after eclosion. Within from four to six hours after emergence males have been observed copulating. Although females do not begin ovipositing for three to four days they may be impregnated soon after eclosion. The flies remain in copulation for as much as an hour in some cases. The extreme sexual precocity of the male is a serious handicap to the use of this species for extensive genetic work requiring controlled matings of diverse stocks.

CYTOLOGY

Metz (1916) first described the metaphase chromosomes as consisting of three rods and a V. Stella (1936) has corroborated this finding. This author has made a study of oogenesis, following the methods used by Guyenot and Naville, and finds that unlike melanogaster no premeiotic and meiotic stages are to be found either in young or old female pupae. Meiosis in immigrans begins after the emergence of the female and can be studied by fixing ovaries from young females. Early embryonic mitoses occur five to six hours after egg-laying.

Emmens (1937) has made a study of salivary gland nuclei in this and three other species.   He finds five chromosome arms as would be expected from the three rods and a V-shaped chromosome in metaphase plates.   He finds the chromocenter to be larger and more diffuse than in melanogaster and funebris.   He describes an element unique in the salivary nucleus of immigrans under the name of "striated body."   This consists of a wide, short element, with four or six bands.   He interprets this as probably consisting of the proximal ends of several or all the chromosomes fused laterally.   The suggestion is also made that this body might consist of fused trabants from several chromosomes.

TABLE I

A LIST OF MUTANTS OF *Drosophila immigrans* DESCRIBED BY VARIOUS WORKERS. Autosomal recessive marked a. r.; sex-linked recessive marked s. r.

	NAME	PHENOTYPIC EFFECT	DESCRIBED BY	DATE
1	Abnormal a. r.	Plexus veins	Bischler and Piquet.	1931
2	Axillary a. r.	Venation	Metz and Metz	1915
3	Brown s. r.	Eye color	Bischler and Piquet.	1931
4	Carmine opaque a. r.	Eye color	Bischler and Piquet.	1931
5	Extra bristles	Dorso-centrals	Bischler and Piquet.	1931
6	Ski	Upturned wings	Bischler and Piquet.	1931
7	Spread a. r.	Wing position	Bischler and Piquet.	1931
8	Truncated a. r.	Bristles	Bischler and Piquet.	1931
9	Yellow s. r.	Body color	Stella	1936
10	.... s. r.	Small-wing	Sturtevant	1921
11	.... a. r.	Small bristles	Sturtevant	1921
12	.... a. r.	Modified veins	Sturtevant	1921
13	.... a. r.	Modified veins	Sturtevant	1921
14	.... a. r.	Modified veins	Sturtevant	1921

GENETICS, SUMMARY OF DESCRIBED MUTANTS

In Table I is given a summary of the data on mutants published up to the present time in this species.   Of the fourteen mutants described, nine were autosomal recessives, three sex-linked recessives and two not analyzed.   Of these only yellow body, sex-linked recessive reported by Stella (1936), is clearly a parallel of mutants found in other species, although the others might well be parallels as they are similar to mutants known for other flies.   The abnormal venation of Bischler and Piquet (1931) and possibly two of the venation mutants reported by Sturtevant (1921) may be alleles at the "net" locus (see below).

GENETICS, NEW MUTANTS

In Table II is given a summary of new mutants, hitherto unpublished. These were found by the author, except for three discovered by Sturtevant and turned over to the author. Sturtevant has also found several other cases of "net," which are probably alleles of those reported here. There follows a brief description of each of the mutants listed in Table II. A number of these have been described briefly in Drosophila Information Service, No. 11, and there assigned a symbol. It is not deemed advisable to publish symbols here as the stocks have been discarded. Consequently anyone in future making a genetic study of this species will not have the confusing situation of avoiding the use of symbols assigned to mutants no longer extant in laboratory stocks. The descriptions are necessarily brief, but it is hoped that they have been made sufficiently specific and clear that they may be used for comparative purposes. Of the thirty-seven mutants described all but four were kept in stock for several generations, either in pure form or through the mating of heterozygotes when sterility was involved. The four not carried in stock were distinct enough in phenotypic effect and appeared in sufficient numbers in F_2 cultures from wild flies to make certain that they were true mutant types and not aberrant forms due to some developmental "accident." Many of the stocks were carried for two years. They have been discarded through the press of other work and the conclusion that the detailed study of linkage in the species was not advisable, owing to the technical difficulty referred to above.

Cherry. Sex-linked recessive. A translucent eye color found in one male of a stock derived from wild flies collected at Gatlinburg, Tennessee. It probably arose as a laboratory mutant not present in the original wild material. Classification easy and viability good.

Singed. Sex-linked recessive. Mutant causing a singing of all bristles and hairs, including marginal bristles of wing. Several singed males were found in a mass culture descended from a pair of wild flies collected in Wooster, Ohio. Females were sterile, males with fair viability and fertility. This seems a clear parallel of singed in melanogaster and other species, and represents a medium to extreme allele.

Brown. Autosomal recessive. A dark eye color, easily classified at eclosion and darkening with age to almost black. The original name given in DIS 3 is retained, although this is more like weak sepia or clot of melanogaster. Found as one female in mass culture from stock of wild flies collected in Wooster.

Burnt. Autosomal recessive. A peculiar mosaic eye color from wild stock, Azusa 17. This and almost all of the remaining mutants

described appeared as several flies segregating out of F_2 mass cultures reared from females either impregnated before capture or mated to a single wild male taken at the same time. The burnt character consisted

TABLE II

A LIST OF *Drosophila immigrans* MUTANTS DESCRIBED IN THIS PAPER

	NAME	PHENOTYPIC EFFECT	FROM WILD STOCK
Sex-linked Recessives			
15	Cherry..............	Eye color.............	Gatlinburg
16	Singed..............	Bristles................	Wooster
Autosomal Recessives			
17	Brown..............	·Eye color.............	Wooster
18	Burnt..............	Eye color.............	Azusa, 17
19	Curly..............	Wing shape............	Azusa, 24
20	Dark..............	Eye color.............	Azusa, 8
21	Extra..............	Venation................	Wooster
22	Extra dorso-centrals.	Bristles................	Woods Hole
23	Extra scutellars.....	Bristles................	Azusa
24	Forked scutellars....	Bristles................	Azusa, 30
25	Grooveless..........	Scutellar groove........	Azusa, 14
26	Irregular...........	Hairs, wings...........	Azusa, 1
27	Irregular...........	Hairs, wings...........	Azusa, 8
28	Javelin.............	Bristles................	Arroyo Seco
29	Minute.............	Bristles................	Rincon, 17
30	Minute mosaic......	Bristles................	Azusa, 5
31	Net................	Venation................	Azusa, 13
32	Net................	Venation................	Azusa, 24
33	Net................	Venation................	Azusa, 29
34	Net................	Venation................	Rincon, 5
35	Net................	Venation................	Rincon, 14
36	Net................	Venation................	Gatlinburg
37	Net................	Venation................	Gatlinburg
38	Net................	Venation................	Woods Hole
39	Ocelliless..........	Bristles, ocelli.........	Azusa, 3
40	Peach..............	Eye color.............	Azusa, 5
41	Peach-like..........	Eye color.............	Azusa
42	Rough..............	Eye texture, veins......	Azusa, 5
43	Rough-like..........	Eye texture, veins......	Azusa, 17
44	Rough-like..........	Eye texture, veins......	Rincon, 8
45	Slight dark.........	Eye color.............	Rincon, 2
46	Slight dark.........	Eye color.............	Wooster, 3
47	Small eye...........	Eye shape, texture......	Rincon, 18
48	Stubby.............	Bristles................	Woods Hole, 43
49	Stubby-like.........	Bristles................	Gatlinburg
50	Two bristle.........	Bristles................	Azusa, 10
51	Two bristle....:.....	Bristles................	Woods Hole, 69

NOTE.—Javelin, net Azusa 13, and peach-like found by A. H. Sturtevant and turned over to the author for study. All other mutants listed here were found in 1937 except brown (1934), cherry (1938), extra (1933), two Gatlinburg nets and stubby-like (1938).

of a dark area of variable size, located near the center of the eye if small; sometimes covering most of the eye. Young, unetherized flies failed to show this. When etherized the burnt area rapidly appeared,

and did not again fade out. Old flies without etherization developed this dark area. Frequently the area had a shiny, seared appearance. The mutant also colored the malpighian tubules a bright salmon. Burnt was somewhat infertile and showed great variability in expression, but with few normal overlaps.

Curly. Autosomal recessive. Wings curled upward as in the dominant Curly of melanogaster. A mutant of very poor viability, and partially sterile. Owing to sterility of females a pure stock was never established. From Azusa 24.

Dark. Autosomal recessive. A dull, dark eye color, somewhat variable and difficult to classify in some cultures. From Azusa 8.

Extra. Autosomal recessive. A slight venation mutant, consisting of small cross-vein or several of these near the distal terminus of the second longitudinal. Normal overlaps. From wild stock collected in Wooster.

Extra dorso-centrals. Autosomal recessive. Two or more extra dorso-central bristles. Variable in expression. This character is frequently met with in wild collections of immigrans but segregated rather definitely in certain wild strains collected from Woods Hole, Massachusetts, while not appearing in others and is consequently listed as a mutant.

Extra scutellars. Autosomal recessive. Extra anterior scutellar bristles of about equal size to the normal ones and lying close to them. Very inconstant in expression. From wild stock of Azusa flies.

Forked scutellars. Autosomal recessive. Anterior scutellars gnarled or forked. Often poorly expressed with many normal overlaps. From Azusa 30.

Grooveless. Autosomal recessive. Similar to the fourth chromosome mutant of this name in melanogaster. When first found the character was well expressed, with the entire lack of a groove between scutellum and thorax. However, there were no dark excrescences on thorax as in melanogaster and hydei. After several generations the expression became less marked with normal overlaps. Since grooveless was recovered from outcrosses modifiers may have accumulated. From Azusa 14.

Irregular. Autosomal recessive. Bristles along margin of wing standing out at a wide angle; hairs on abdominal tergites disarranged; hairs on thorax disarranged; wings somewhat shorter than normal and held out at an angle. Similar to mutant by same name described by Chino (1929) in Drosophila virilis, and found by the author in hydei, melanogaster, robusta, and an undescribed species in the repleta group (all unpublished). This seems to represent an extreme type by comparison with the others. From Azusa 1.

Irregular. Autosomal recessive. Bristles along margin of wing standing out at wide angle; hairs of abdominal tergites slightly disarranged, but thoracic hairs normal and wings only slightly shortened. A slight allele as shown by mating tests with extreme irregular. From Azusa 8.

Javelin. Autosomal recessive. Mutant found by A. H. Sturtevant in wild stock from the Arroyo Seco, a canyon in the San Gabriel mountains near Pasadena. Bristles long, not tapering at the end as in wild-type; often hooked at end. Similar to mutant of same name in melanogaster.

Minute. Autosomal recessive. Very small bristles; low viability and fertility; pure stock not established. From Rincon 17.

Minute mosaic. Autosomal recessive. Small bristles in a mosaic pattern; anterior scutellars most often affected; less frequently dorsocentrals and head bristles; pattern seemed to show no symmetry. From Azusa 5.

Net. Autosomal recessive. Found by A. H. Sturtevant in his stock Azusa 13, from a single female collected near Azusa. This was a very extreme net venation with a heavy plexus over most of the surface of the wing, and particularly concentrated around the posterior cross-vein and along margin of wing between first and second longitudinals. Although there was much variability in a culture all flies showed the character in extreme form. This mutant in some cases showed weak net manifestation in heterozygous form when crossed to stock showing no visible net, indicating that extreme net, Azusa 13, is partially dominant to some phenotypically wild-type alleles.

Net. Autosomal recessive. This and the following cases of net seem to represent various alleles at the frequently mutating net locus in this species. While tests for allelism were not made in all combinations, in cases where they were made the results were consistent with the view that there was a large series of multiple alleles at the net locus, distributed through wild populations. This is a situation somewhat similar to the case of the multiple allelic series of "bobbed" in Drosophila hydei (Spencer, 1937). This was a net of medium grade of expression, with plexus of veins developed around posterior cross-vein. From Azusa 24.

Net.' Autosomal recessive. Weak expression, but no normal overlaps. Small sections of vein around posterior cross-vein and between first and second longitudinals. From Azusa 29.

Net. Autosomal recessive. Medium expression. From Rincon 5.

Net. Autosomal recessive. Medium to weak expression. From Rincon 14.

Net. Autosomal recessive. Medium to weak. From Gatlinburg.

Net. Autosomal recessive. Weak expression. From Gatlinburg.

Net. Autosomal recessive. Very weak expression. Recovered in ten cases from tests of 156 wild flies from Woods Hole. In appearance these all seemed very similar and might readily have come from a single source (see discussion below).

Ocelliless. Autosomal recessive. Similar to mutant of the same name described by the author in Drosophila funebris (Spencer, 1928). Hairs sparse on thorax and abdomen, wing marginal bristles ragged; ocellar bristles sometimes missing; ocelli may be missing or run together; eye pile sparse; wings thin textured; sometimes hairs or bristles doubled and coming from same basal ring; partially sterile and inviable. From Azusa 3.

Peach. Autosomal recessive. Translucent eye color when newly emerged; darkening with age. From Azusa 5.

Peach-like. Autosomal recessive. Translucent eye color, somewhat easier to classify than peach. Found by A. H. Sturtevant in Azusa wild stock.

Rough. Autosomal recessive. Extreme rough eye; venation ragged and wings thin textured. Semi-sterile. From Azusa 5.

Rough-like. Autosomal recessive. Similar to rough of Azusa 5, but less extreme. Allelism not tested due to difficulty of breeding rough. From Azusa 17.

Rough-like. Autosomal recessive. Almost identical to rough of Azusa 5, but allelism not tested. From Rincon 8.

Slight dark. Autosomal recessive. Dark eye; not as extreme as brown and frequently difficult to classify. From Rincon 2.

Slight dark. Autosomal recessive. Phenotypically similar to slight dark from Rincon 2; allelism not tested. From Wooster 3.

Small eye. Autosomal recessive. Small, rough eye with anterior scutellars missing on most flies. Inviable and sterile. From Rincon 18.

Stubby. Autosomal recessive. All head and thoracic bristles short and thick. Viability and fertility good, and classification easy. From Woods Hole 43.

Stubby-like. Autosomal recessive. Similar to stubby of Woods Hole 43. Allelism not tested. From Gatlinburg.

Two bristle. Autosomal recessive. Anterior dorso-central bristles missing. Good expression, but with a few normal overlaps. The species often gives expression to extra dorso-centrals. This mutant has a phenotypic effect opposite to the general trend of the species. From Azusa 10.

Two bristle. Autosomal recessive. A mutant similar to the one just described but with many more normal overlaps. From Woods Hole 69.

In addition to the above mutants the author has recorded several cases of weakly expressed and inconstant hereditary types. In any study of visible mutants it becomes obvious that there are many grades ranging from those which under any environmental conditions which will allow for the development of the flies show a constant and uniform character expression to those inherited tendencies which give no visible effects under some conditions and only feeble and inconstant characters under other conditions. In spite of this range of character expression it is possible to list in a given investigation those mutants which show about the degrees of expression at a phenotypic level generally worked with by students of Drosophila genetics. The argument is sometimes advanced that lethal genes can be handled more objectively. However, to those familiar with the gradations from what appear to be 100% recessive lethals, through semi-lethals which under slightly adverse culture conditions show 100% lethal expression, to mutants of low viability, this argument should have little weight. The accuracy of the comparison and contrast of data collected from different sources, as in the study of diverse populations reported here, will depend less on where the line

is drawn as regards classifying of attenuated phenotypic effects as mutant types, than on drawing that line at about the same point for all sets of data under consideration. Furthermore, a thorough familiarity with the peculiarities exhibited by a species under various conditions of culture, against a background of experience gained through the study of other species, is probably more important than the setting up of arbitrary rules of classification to be followed blindly. While it may appear to be a dangerous practice it is none the less important that an investigator be prepared to evaluate results from a particular experiment in terms of all that he knows of possible factors involved in giving the results.

At best, however, it is impossible to carry on investigations which deal either with the origin of new mutants or the distribution of mutants already present in a population without some subjective error. These errors are less when the amount of data treated is large, and when the data are collected by one rather than by several workers.

LINKAGE STUDIES

The X-Chromosome. The sex-linked recessives, brown eyes (Bischler and Piquet, 1931), cherry eyes (Spencer), small wing (Sturtevant, 1921), singed bristles (Spencer), and yellow body (Stella, 1936) have been recorded. However, these mutants were found at various times in widely separated laboratories and no linkage studies on the X-chromosome have been carried out. Singed and yellow are clearly parallels of mutants found in the X of many other species, and the others might well be parallels, although their identity is not so readily determined.

Autosomal Linkage. Bischler and Piquet (1931) report linkage between spread wings and carmine opaque eyes.

Sturtevant (unpublished) found that net and brown were linked.

I have added to this linkage group the gene rough, Azusa 5, and find that peach, Azusa 5, and javelin are in the same linkage group and not linked to brown-net-rough.

Thus three of the four expected linkage groups have been established from the investigation of a few of the mutants reported here. The author made preliminary attempts to secure further linkage data, but these were unsuccessful owing to the difficulty of securing virgin females for tests, as noted above.

No cross-over data are available, and the genetic chromosomes of this species remain wholly unmapped,   Linkage studies on. *Drosophila immigrans* would be possible, but could only be carried through successfully by one with much time available for the work.

GENETIC STRUCTURE OF POPULATIONS

The new mutants found by the author have been extracted from five geographically distinct populations. It is realized that the samples studied were inadequate in size and that the method of analysis was less accurate than those used by Dubinin and collaborators (1934), Gordon (1936), and the Timofeeffs-Ressovsky (1927) for the analysis of visibles in *Drosophila melanogaster* populations, or of Spencer (in press) for similar work on *Drosophila hydei.*

Wild flies were trapped at Camp Rincon, San Gabriel Canyon, Southern California; a large citrus dump near Azusa, Southern California; Gatlinburg, Tennessee; Woods Hole, Massachusetts (two stations); and a refuse dump from a canning factory, Wooster, Ohio.

The method of analysis consisted of rearing an F_1 generation either from a female impregnated before capture or from a pair of flies taken from traps and mated in the laboratory.   One or two F_2 mass cultures were reared from about a dozen of the F_1 flies. Neither lethals nor chromosomal variations were studied. If random mating occurred among the F_1 flies, then approximately one-sixteenth of the F_2 flies should be homozygous for a given recessive autosomal mutant carried in heterozygous form by one of the original parents. The inaccuracy of the method consists in part in the practical certainty that the F_2 flies are not produced at random from all the F_1 parents used. This has been proved when the method of rearing the F_2 from several separate pair matings is directly compared to the F_2 mass culture method. However, as the same technique was used throughout these analyses are directly comparable.

Table III summarizes the results from the several populations as to the number of flies tested from each region and the number of separable visible mutants or alleles of these recovered. In this table the chi square test has been applied to determine whether the distribution of visible mutants recovered is random for the five populations studied. By this test it is found that the distribution is far from random, the deviations

being highly significant. A much larger group of mutants was discovered for the size of the sample taken from Azusa than for the sample from Woods Hole. The Wooster and Rincon populations show small deviations from expectation, while the Gatlinburg population contained very nearly the same proportion of mutants as that found for all the samples together.

These facts may be explained by reference to the pattern of the populations in question. At Woods Hole the species is probably killed off outdoors in the winter. The Woods Hole collections taken at two trapping stations about one-half mile

TABLE III

Summary of Wild Flies Tested and Autosomal Recessive Mutants Recovered from Five Geographically Distinct Populations of *Drosophila immigrans* and Calculation of Chi Square as a Test of Their Random Distribution

LOCALITY OF POPULATION	TOTAL NUMBER WILD FLIES TESTED, n	NUMBER OF DISTINCT MUTANTS RECOVERED, X	NUMBER OF MUTANTS EXPECTED m	$\dfrac{362}{330} \cdot \dfrac{(X-m)^2}{m}$
Azusa, California............	60	16	5.304	23.661
Camp Rincon, California....	56	6	4.950	0.245
Gatlinburg, Tennessee......	44	4	3.890	0.003
Woods Hole, Massachusetts	156	4	13.790	7.624
Wooster, Ohio..............	46	2	4.066	1.152
Totals................	362	32	32.000	32.69 = χ^2 d. f. = 4

Probability of chi square being 13.277 or greater is 0.01; as chi square is actually 32.69 the deviation from a chance or random distribution of distinct mutants in the five populations is such as would happen much less often than once in 100 trials and is clearly significant.

apart in late July came in all probability from small local foci which had overwintered indoors. The fact that a net mutant of mild expression was found ten times in the sample of 156 flies tested is indicative of this. Two other mutants were also found several times. In all only four distinct types were recovered. In contrast sixteen distinct mutants were extracted from 60 flies tested from Azusa. Here the species survives the year round outdoors, although the population must be markedly decreased during the hot, dry summer. The effective breeding population at the Azusa citrus dump is quite conceivably much larger than that of Woods Hole, where the breeding aggregate

contracts yearly into an indoors "bottle-neck." These data are in line with the mathematical analysis of Wright (1931) on the breeding structure of Mendelian populations. The figures are small and the analysis somewhat faulty. However, the evidence presented here indicates the importance of the size of populations at different times of the year in determining their genetic structure.

SUMMARY

1. The taxonomic position of *Drosophila immigrans* is reviewed.

2. Known facts of its distribution in Europe, Asia, and North America are given.

3. Collection data show that in mild seasons the species may over-winter outdoors in northern Ohio; in severe winters it survives only in buildings. This affects the structure of the summer and autumn populations in a given season.

4. Immigrans forms small, local aggregates in breeding grounds where *Drosophila hydei* is the dominant form.

5. The species tolerates higher temperatures outdoors than in bottle cultures, probably due to better ventilation.

6. Larvae and adults are very sensitive to acidity and to accumulation of carbon dioxide. Larvae grow well on a "kleenex" yeast suspension medium.

7. Males show extreme sexual precocity, making controlled matings of diverse stocks difficult.

8. The cytology is reviewed briefly. There are three pairs of rods and one pair of V-shaped chromosomes. The salivary chromosomes show five long elements.

9. A summarized table of 14 mutants from descriptions in the literature is given.

10. A table and brief descriptions of 37 new mutant types are presented.

11. Of these a multiple allelic series at the "net" locus is most interesting. Evidence presented indicates that net is widely spread throughout immigrans populations.

12. Sex-linked yellow and singed are clear parallels of mutants of the same names in other species. Other parallels are not so evident.

13. In Table III appears a summary of the genetic analysis for recessive visible mutants present in 362 wild flies from populations at Camp Rincon and Azusa, Southern California; Gatlinburg, Tennessee; Woods Hole, Massachusetts; and Wooster, Ohio.

14. The chi-squared test shows that the mutants recovered were not distributed at random to these five populations.

15. The excess of mutants at Azusa and their scarcity at Woods Hole are interpreted in terms of the breeding structures of the populations involved.

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TWO NEW BUPRESTIDAE

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Dystaxiella n. gen.

I propose this genus for a species which appears to be intermediate between *Glyptoscelimorpha* and *Dystaxia*. From the former genus, which it more closely resembles, it differs by the cleft tarsal claws and the large white scaly vestiture. From the latter genus it differs by the convex pronotum and lack of dense, coarse dorsal punctures.

Genotype *Dystaxiella juniperae* n. sp.

Dystaxiella juniperae n. sp.

Male.—Form of *Glyptoscelimorpha marmorata* Horn, but larger, brunneous throughout with exception of eyes which are dark mottled with irregular light areas, clothed with recumbent elongate scales which are more abundant on the ventral surface and partly conceal the punctures.

Head convex, a median line on vertex; clypeus broadly emarginate in front; surface densely, finely punctured, punctures separated by more than their own diameters; antennae reaching nearly to middle of elytra when laid along sides, scape stout, second joint about twice as long as wide, third joint longest, following joints decreasing in length, joints five to eleven inclusive serrate.

Pronotum nearly twice as wide as long, much wider at base than at apex, widest at base; sides constricted at apex, broadly rounded to base; disk convex, lateral marginal carina obsolete in front; surface densely punctured, punctures larger than those of head. Scutellum triangular, glabrous.

Elytra at base much wider than pronotum, widest back of humeral angles, sides rounded in front, constricted about middle, broadly rounded posteriorly to rounded apices; disk convex; surface densely punctured, punctures same size as those of head.

Abdomen beneath densely finely punctured, last abdominal segment with a deep V-shaped emargination. Tarsal claws with a tooth on the inside near the apex of each claw.

Length 9.3 mm.; width 4 mm.

Female.—Differs from the male by the rounded last abdominal segment and the shorter antennae which reach just beyond the hind angles of the pronotum.

Described from specimens taken on juniper (*Juniperus* sp.) at Mountain Springs, California, July 26, 1940, by D. J. and J. N. Knull. Type material in collection of writer.

Cinyra cuprescens n. sp.

Male.—Robust, convex, dark cupreous throughout.

Head convex, no depressions; surface with very large punctures; clypeus broadly emarginate; surface clothed with white pubescence; antennae reaching past middle of pronotum when laid along side; serrate from the fourth joint.

Pronotum wider than long, wider at base than at apex, widest back of middle; sides widened posteriorly, nearly parallel at base; anterior margin slightly sinuate, median lobe very broad; basal margin sinuate, median lobe broad; disk convex, lateral marginal carina obsolete in front; surface coarsely punctured, punctures more numerous on sides, separated by less than their own diameters in center, pubescence inconspicuous. Scutellum oval, glabrous.

Elytra wider than pronotum, widest back of middle; sides rounded in front, constricted near middle, broadly rounded posteriorly, apices emarginately truncate, outer angles acute; disk convex, basal depressions slight; surface striate, interspaces coarsely irregularly punctured, punctures not as large as those of pronotum, pubescence inconspicuous.

Abdomen beneath coarsely confluently punctured, densely pubescent, last abdominal truncate.

Length 10.7 mm.; width 3.2 mm.

Female.—Differs from male by being larger in size, with more convex abdomen and antennae not reaching middle of pronotum when laid along side.

Material collected in the Tucson Mountains, Arizona, August 18–19, 1940, by D. J. and J. N. Knull. Holotype male, allotype and paratypes in writer's collection, paratypes in collection of the U. S. National Museum and The Ohio State University.

This species is close to *C. purpurascens* Schffr. Mr. W. S. Fisher kindly compared a specimen with the type and stated that the latter species has a more strongly convex pronotum which is more deeply, confluently punctured. The clypeus is more deeply, subangularly emarginate in front. The tips of the elytra are deeply emarginate with the teeth strongly produced.

BOOK NOTICES

Social Problems

This book is offered as a text on what is called the growing rapprochement between the biological and the social sciences. The first 11 chapters would do well as a textbook of genetics. The other 10 chapters treat of intelligence, race problems, population problems, medical problems, insanity, crime, education, and government—all in relation to heredity as the author views that relationship.

Within his own frames of reference, Professor Burlingame is altogether fair, but his frames of reference, and therefore his orientation and his net emphasis, are the familiar ones of those eugenists who believe that the mentally deficient and the dull members of society are, in and of themselves, sources of social evils. Psychologically, this belief is nothing other than "projection," defined as blaming some group of persons different from one's own associates for difficulties which are by no means of that group's making. It may be a very human failing, but it is no less a failing, and one from which the eugenics movement has long suffered. The naive student will see in this book support for the too easy notion that the feebleminded and other deviate groups in our population are *verae causae*, in the sense that if only suitable negative selective measures could be applied to such groups, social matters would automatically be improved.

In so far as genetical science has something important to contribute to the subject, it is that the "tail" of the population's distribution comprising our "dull" and "unadjusted" groups is certainly going to remain with us, even when we succeed in greatly improving our average biological lot by effective eugenic measures. Since the whole problem is obviously a relative rather than an absolute matter, one can expect that, if anything, not fewer but *more* of the relatively dull and unadjusted members of society will be recognized when substantial eugenic progress has been made.

And if the social sciences have anything to say on the problem, it is that the dull and unadjusted are in any case not the causes of social conflicts. Even if it were possible to remove these groups from the population for a generation, we might thereby deprive some eugenists of a bogey of which they are fond, but the operation would leave virtually unaffected the larger social issues which Professor Burlingame has ventured to discuss. The solution of the problem of our deviate groups lies, not in exaggerating the financial costs of these individuals to society as a whole—which costs are, in sober fact, very small—nor in entertaining scapegoatological attitudes towards them, but in facing squarely the need for greatly improving our supervisory and institutional facilities.

This is not to say that eugenic progress is not very much worth working for. It is to say that Professor Burlingame has presented wrong reasons for eugenic measures of any kind; and worse, he does not seem to know what sound and effective eugenic measures would be. In this book, published several years after the American Eugenics Society inaugurated its contemporary program (1935), one looks in vain for any reference to that organization's efforts to set up measures which would have favorable selective effects on the full range of genotypes in the population's distribution.

Much of the material in the latter half of the book centers around differential birth rate statistics. On this, the student would never suspect that Francis Galton, R. A. Fisher, and others have pointed out that the "social promotion of infertility" is a marked phenomenon in any such society as ours. Clearly, persons of higher socio-economic status are frequently of that status as much because of their infertility as by virtue of genetic capabilities. This fact renders dubious most of the argumentation from data on differentials in the birth rate, which data the author would apparently have the student take at face value as indicating dysgenic trends.

Included without criticism are the ideas of Raymond Cattell to the effect that the mean genetic intelligence of such populations as ours and England's may be declining several IQ points per generation. These claims involve the old fallacy that the test-intelligence of children is somehow independent of their home and school

background and may therefore be taken as a perfectly sound measure of genetic variation.

Also included without either criticism or citation of author are the "scare" statistics derived by Caroline Robinson and published by the Journal of Heredity; they are figures to the effect that many persons are dependent on others, and they are stated as if such facts were somehow peculiar to our society! Many parts of the important data assembled by Lorimer and Osburn are presented, but with much less of the care and caution which those authors used in interpreting the same materials in their *Dynamics of Population*. Professor Burlingame's treatment of such sociological problems as arise in connection with Negro and Jewish groups is scarcely felicitous. On the whole, the author's emphases seem to this reviewer to be wide of the mark for leading to significant improvements in either biological or social directions.

Professor Burlingame calls upon social scientists to do something about genetic dangers seen by him. Yet no mention is made of such a reference as Julian Huxley's important Galton Lecture of 1936, in which the classical eugenists were urged to learn the methods as well as the concepts of the sociologists. There is shown in the book little understanding of what modern eugenists and social scientists have been saying and doing for years. It is regrettable that the author's efforts are much more likely to be confusing than enlightening to those for whom the book was written.—*B. Price*.

Heredity and Social Problems, by L. L. Burlingame. xi+369 pp. New York, the McGraw-Hill Book Co. 1940. $3.50.

A New Viewpoint on Eugenics

Eugenics has traveled a rocky road through the years since genetics first gave an impetus to the belief that somehow it might be possible to have more and more children born to those persons who make the most effective response to their environments, and fewer and fewer to those who respond less effectively. Many eugenic proposals have been made on insufficient data, on poorly thought-out premises, or by those who did not have the training and background necessary for the formulation of such policies. Consequently there have been many attacks on eugenic proposals, some of which have included counter-proposals even more radical and unscientific than those they sought to replace.

The author of the present volume approaches the subject sanely, including only such scientific data as are confirmed and weaving his policy into the already accepted ideals and population trends of the American people. He makes it clear that eugenic selection should be encouraged not between socio-economic groups, but within all such groups. Children in all groups are entitled to be born to parents who want them, who will care for them properly, and who will give them good heritage. Such ideals can come about only with community help to all children, involving not only education, but nutrition, medical care, adequate home and recreational environments and many other things.

This book stands out like a beacon light among treatises which are biased, prejudiced or confined to narrow limits. It should be read by all parents, teachers, and especially by those who help to formulate population policies of any sort.—*L. H. S.*

Preface to Eugenics, by Frederick Osborn. xi+312 pp. New York, Harper and Bros. 1940. $3.00.

Elementary Chemistry

The text is designed for a year's course in elementary chemistry. The treatment of descriptive chemistry is well organized and is not overburdened with detailed listings of properties which are not of general interest. The outlines for study, the diagrammatic summaries and review sections are excellent both from the standpoint of the student and the teacher. The illustrations are good but it is unfortunate that the publisher has chosen to place groups of these on individual pages rather than at pertinent points within the body of the text. The chapters on "Valence, Nomenclature, Graphic Formula" and "Chemical Equilibrium" are to be commended.

Since one of the purposes of the book from the student viewpoint is to "enable him to continue in any of the specialized branches of the science" certain omissions in theoretical discussions seem hard to justify. After a lengthy and good discussion of acids and bases from the older viewpoint, a very sketchy treatment of the widely used Brönsted theory is given with the statement that "while the Brönsted theory is broader in scope and invaluable in research, it is of theoretical interest only to students in general chemistry." In the earlier part of the same chapter, in the discussion on ionization, it would seem desirable to have pointed out that the treatment given applies to weak electrolytes and to have made some mention of the newer treatments which give an approach to strong electrolytes. Objection seems justified to the use of "bound" and "free" protons in atomic structure, with neutrons listed only as "additional nuclear units." Finally, the development of the Periodic Law does not take sufficient cognizance of the fact that certain of the objections to the Mendeléef form of the Periodic Table may be at least partially removed by the use of more extended forms.

With the above exceptions the book is very well done. It is only fair to point out that the questions raised concern matters about which considerable controversy has arisen as to the method and place of presentation to the student.

—*J. P. McReynolds.*

Essentials of College Chemistry, by G. H. Whiteford and R. G. Coffin. 534 pp. St. Louis, The C. V. Mosby Co. 1939. $4.00.

Technical Terms and Their Meanings

Certain words or expressions have special meanings and special significance to a person skilled or trained in a branch of knowledge relating to some particular human activity or some particular aspect of nature. Such words or expressions are "technical terms," and are understandable by one not especially versed in the field only through personal explanation or through the medium of a glossary. Glossaries are available for many specialized fields, but there is need for a comprehensive dictionary of broader scope. This need seems adequately met by Chamber's Technical Dictionary. It includes many thousands of terms from the various sciences, from medicine, from engineering, from manufacturing, from construction and from other fields having technical vocabularies. As is only proper, these terms have been defined by specialists engaged in the practice or teaching of their various fields. The list of contributors is an imposing one. The reviewer looked up a random sample of words in the fields with which he is familiar, and found nearly all of them listed, and carefully and accurately defined. The book is one which any teacher or research worker will find invaluable on his desk, and will undoubtedly refer to frequently. An appendix includes the Greek alphabet, a table of chemical elements, the periodic table, tables of igneous and sedimentary rocks, and outlines of the animal and vegetable kingdoms.—*L. H. S.*

Chamber's Technical Dictionary, edited by C. F. Tweney and L. E. C. Hughes. viii+957 pp. Cambridge, at the University Press; in New York, the Macmillan Co. 1940. $5.00.

Insect Transmission of Plant Diseases

The border line subject matter between entomology and plant pathology which deals with insects and their relationship to the transmission of plant diseases is admirably presented in a pioneer textbook entitled "Insect Transmission of Plant Diseases" by J. G. Leach, Professor of Plant Pathology at West Virginia University.

It is apparent that the author possesses fundamental knowledge concerning insect structure, physiology and behavior for he presents the subject matter relating to insects in a very satisfactory manner.

One only needs to hastily scan the contents of the book to be impressed with the magnitude of the field. Careful reading of almost any portion, particularly the chapters on insects and bacterial, fungus and virus diseases, reveals the fact that the author has covered a vast amount of literature and he presents the significant facts in a manner which should be satisfactory to most entomologists and plant

pathologists.   He carefully cites the names of all authors whose opinions or findings he quotes.

Each chapter is followed by a list of the most important references.   At the end of the book the author includes several interesting tables.   Table I lists the more important diseases and the insect vectors of each, while Table II lists all possible vectors and the diseases each may transmit.   A glossary of terms used in the literature cited is found at the end of the book.

The reviewer has read the entire book and has profited considerably by so doing.   Professor Leach has made a splendid contribution for entomology and plant pathology and is to be congratulated.—*A. Peterson.*

Insect Transmission of Plant Disease, by J. G. Leach, 615 pp., New York, the McGraw-Hill Book Co.   1940. $6.00.

Introduction to Entomology

In this latest revision of Comstock's classic entomology text the only major changes have been in the chapter on the Hymenoptera.   The discussions of the superfamilies Ichneumonoidea, Proctotrupoidea, and Chalcidoidea have been revised and extended, and keys to the subfamilies of Ichneumonidae and Chalcididae have been included.   There is a new key to the families of Chalastogastra, and a short key to the commoner families of Clistogastra has been added.   A great many bibliographic references on the parasitic Hymenoptera have been cited in this chapter, while the principal bibliography, at the end of the book, is unchanged. The text and keys for this new matter was contributed by Dr. Henry K. Townes. These changes will make the book more valuable particularly to those interested in the parasitic Hymenoptera.

There are still a few typographical errors in this edition, particularly in page references, though most of the errors of earlier editions have been corrected.   The index has been completely revised.   Like the preceding editions, this one is well bound to withstand the hard usage it is likely to get.—*D. J. Borror.*

An Introduction to Entomology, by John Henry Comstock.   xix+1064 pp. Ithaca, Comstock Publishing Co.   Ninth Edition Revised, 1940. $5.00.

Physics from a New Viewpoint

Smyth and Ufford present an entirely new approach to the teaching of physics in their book, Matter, Motion, and Electricity.   That which immediately distinguishes their volume from others is the use throughout of the m.k.s. system of units and the introduction of topics in a sequence quite different from the usual one.

The authors believe that the use of the m.k.s. system of units is a definite step forward.   This may indeed be true since it leads to the exclusive use of the practical system of units in electricity, and this is certainly a desirable feature.   This reviewer is inclined to feel that what is here gained may be lost elsewhere, but this may be prejudice.   Probably only a test of the system can actually decide what are advantages and disadvantages.

Chapter I, which has the caption, Atoms and Molecules, is devoted principally to the atomic and molecular picture of chemical combination.   It is followed by a chapter on the motion and sizes of molecules and with the forces that exist between them.   The subject of forces and motion is further expanded upon in the subsequent four chapters; the gravitational law of Newton being introduced to clarify the concept of mass and weight.

Subsequent chapters are devoted to the subject of electricity.   The use of the m.k.s. system of units facilitates this since this makes unnecessary the reference to the troublesome e.s.u. and e.m.u. system of units.   Such subjects as rotational motion and simple harmonic motion are first introduced in these chapters.   The subject of rotational motion occurs in the portion devoted to the motion of electrons in a magnetic field and simple harmonic motion is introduced in the section dealing with alternating currents.   Whether the introduction of such subjects at points where they are first needed is the most elegant procedure or not is probably debatable, but

it should certainly appeal to the student who is always wondering about what good these things are anyway, when treated in the conventional sequences.

The book is intended for students who have had a thorough course in high school physics and algebra. Use of trigonometry is frequent and incidental references to the notation of differential calculus are made at appropriate points.

—*H. H. Nielsen.*

Matter, Motion and Electricity, by H. D. Smyth and C. W. Ufford. 648+xiii pp. New York, the McGraw-Hill Book Co. 1939. $3.75.

A Science Teachers Handbook

Teachers of chemistry, physics, general science or biology should find this new book of great value. Section I contains eight chapters dealing with philosophy of science teaching, objectives, psychology, methods, laboratory and demonstration, reading, evaluation, and science clubs. Here the authors have presented a quantity of material in relatively short space which makes careful reading essential but well worth while. The approach is a departure from the traditional methods book, for which much credit must be given to the work of the Science Committee of the Commission on Secondary School Curriculum of the Progressive Education Association. Section II comprises a discussion of devices and materials for teaching science, including the psychology of visual aids, the school journey, flat pictures and stereographs, photography, objects, specimens and models, designed materials, the microscope, the telescope, and projection machines. Section III is devoted to a tabular presentation of sources of materials for teaching science, such as flat pictures, models, etc., charts, books, reference books, textbooks and periodicals. Such a book should certainly be a part of every science teacher's library.

—*Paul E. Schaefer.*

Modern Methods and Materials for Teaching Science, by Elwood D. Heiss, Ellsworth S. Obourn and C. Wesley Hoffman. 351 pp. New York, The Macmillan Company. 1940. $2.50.

American Mammals

The lives, habits, and economic relations of North American Mammals are ably presented in a recent book of this title by W. J. Hamilton, Jr., of Cornell. Widely recognized for his field studies of small mammals, the author has incorporated his own knowledge of ecological relationships along with that of others into a comprehensive and authoritative discussion. Beginning with a general discussion of prehistoric mammals in North America and the probable ecological conditions in which they lived, Hamilton thereafter deals with many phases of present day mammalian life.

Especially noteworthy are the chapters on food, reproduction, migrations, populations, distribution, and behavior. Order and family characters are listed in one chapter in only sufficient detail to orient the student to them. Economic relations are presented under the four topics of useful, injurious, game and fur-bearing mammals. The material is written in a readable style, attractive and stimulating to students. Occasionally the reader is led to feel that details have been sacrificed in the attempt to cover the many phases of a very broad subject. However, the situation has been met by continual references to the literature and by placing extensive bibliographical lists at the end of each chapter. The drawings, photographs and charts are numerous and well chosen. Undoubtedly, Professor Hamilton has made a noteworthy contribution to North American Mammalogy, in bringing together in one volume a digest of our present knowledge of this broad subject, so widely scattered in the literature. His book deserves a place in the library of every student of Mammology.—*John W. Price.*

American Mammals, by W. J. Hamilton, Jr., xii+434 pp. New York, the McGraw-Hill Book Co. 1939. $3.75.

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